# SMALL HYDRO POWER RESOURCE IN THE PROVINCIAL SYSTEM

## Economic & Financial Assessment

### Canadian Cataloguing in Publication Data

Main entry under title:
Small hydro power resource in the provincial system

(Energy conservation and technology projects, ISSN 0823-4973)

Includes bibliographical references.
Contents: Technology and resource assessment -- Economic and financial assessment / Sigma Engineering Ltd., Robinson Consulting & Associates Ltd.
"SEL 5242"; "SEL 5276"
ISBN 0-7718-8415-X (set). -- ISBN 0-7718-8416-8 (v. 1). -- ISBN 0-7718-8417-6 (v. 2)

1. Hydroelectric power plants - British Columbia. 2. Electric power production - British Columbia. 3. Hydroelectric power plants - Economic aspects - British Columbia. 4. Electric power production - Economic aspects - British Columbia. I. Sigma Engineering Ltd. II. British Columbia. Energy Resources Branch. Conservation and Technology Division. III. Robinson Consulting and Associates. IV. Series.

TK1427.B7S62 1984 333.79'32'09711 C84-092074-1

# ADVICE AND DISCLAIMER

This report was funded and published by the Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia, as a public service. Although it is believed to be accurate, the Ministry does not warrant the accuracy of its contents. The Ministry does not guarantee or assume any liability for the effectiveness or the economic benefits of the processes or data described in the report.

Readers are advised that rights to the use of processes or data referred to may be privately held.

Note: As some of the maps have been reduced for this reproduction, map scales are not necessarily accurate.

First printing, February 1984

PROVINCE OF BRITISH COLUMBIA

MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

# SMALL HYDRO POWER RESOURCE
# IN THE PROVINCIAL SYSTEM

## ECONOMIC AND FINANCIAL ASSESSMENT

SEL 5276
JULY 1983

SIGMA ENGINEERING LTD
ROBINSON CONSULTING & ASSOCIATES LTD

## FOREWORD

The Financial and Economic Assessment of the provincial small hydro power resource was initiated as a logical follow-up to the Technology and Resource Assessment. In recognizing that small hydro would have to be an economically viable source of energy before it could replace or supplement traditional electrical energy supplies, the report was required to put the magnitude and importance of the resource in perspective.

At the time of writing the main body of the report (mid-1982), the comparison was made with the proposed Site C project near Fort St John on the Peace River. This project was the next in line in terms of BC Hydro's development plans, providing the lowest cost of energy for any of the foreseeable options for meeting provincial load growth. Accordingly, the small hydro resource was evaluated on the basis of being able to provide power at a comparable rate with Site C, in which case it could defer the need for Site C for at least several years and also provide a better match with provincial load growth. Off-grid small hydro resources were also compared with the cost of diesel fuel used for generating.

The current recession changed much of the thinking about provincial load forecasts. Electricity sales dropped and the long term load forecasts were revised downward. BC Hydro suffered operating losses and began to reduce staff. The commissioning of the Revelstoke project in 1984 with no immediate domestic need for its capacity worsens the situation. The Site C project has been deferred indefinitely and BC Hydro is making efforts to sell its surplus power thereby avoiding transferring the burden of higher operating costs to the consumer.

All of these factors may be considered negative in respect of the development of the small hydro power resource in British Columbia. However, it really means that additional time is now available in which to formulate policies for the development of the resource. The sites will not deteriorate nor will using electricity go out of style so the resource value will remain intact. The value of small hydro to replace diesel systems will continue to be attractive.

Despite the fact that many of the conditions present at the time of first writing the report have changed, the objective of the study is not diminished. A significant proportion of the resource has been determined to be viable in comparison with other sources of electrical energy, both for future expansions of the grid system and to replace diesel generation.

# CONTENTS

1. INTRODUCTION

2. ECONOMIC ASSESSMENT OF THE SMALL HYDRO POWER RESOURCE
    - 2.1 Costs
    - 2.2 Economic Benefits of Small Hydro Power Development and Economic Feasibility
    - 2.3 Sensitivity Analysis
    - 2.4 Off-Grid Applications

3. FINANCIAL ASSESSMENT OF THE SMALL HYDRO POWER RESOURCE
    - 3.1 Factors Influencing Financial Feasibility
    - 3.2 Financial Feasibility Analysis of a Typical Project
    - 3.3 Financial Feasibility of the Small Hydro Power Resource

4. POLICY OPPORTUNITIES TO MATCH THE ECONOMIC AND FINANCIAL FEASIBILITY OF THE SMALL HYDRO POWER RESOURCE
    - 4.1 Objectives of Policy
    - 4.2 Policies

5. CONCLUSIONS AND RECOMMENDATIONS

## LIST OF FIGURES

1.1 Mean Monthly Power Output as percent of Installed Generating Capability vs Month of Year.

1.2 Quantity of Small Hydro Power vs Number of Sites.

2.1 Small Hydro Power Resource:
Incremental Energy Capability vs Incremental Cost of Power.

2.2 Geographic Distribution of the Lowest Cost Small Hydro Power Sites.

2.3 On-grid Small Hydro Power:
Incremental Energy Capability vs Incremental Cost of Power (at point of grid connection).

2.4 On-grid Small Hydro Power:
Incremental Energy Capability vs Incremental Cost of Power (at point of delivery to consumer).

2.5 Illustration of Phased Small Hydro Power Development compared to Site C in meeting Projected Energy Requirement.

2.6 On-grid Small Hydro Power:
Incremental Energy Capability vs Incremental Cost of Power (Sensitivity to discount rate).

2.7 On-grid Small Hydro Power:
Incremental Energy Capability vs Incremental Cost of Power (Sensitivity to maintenance cost).

2.8 Cost of Site C Power vs Export Price.

3.1 On-grid Small Hydro Power:
Quantity of Financially Feasible Power vs Price of Power.

4.1 Impact of Financing on Quantity of Feasible On-grid Power.

4.2 Impact of Water Rent on Quantity of Feasbile On-grid Power.

4.3 Impact of required Rate of Return on Quantity of Feasible On-grid Power.

# LIST OF TABLES

2.1 Incremental Loss Multipliers.

2.2 Small Hydro Power Potential near BC Hydro Diesel Grid Areas.

3.1 Sample Inputs to Small Hydro Financial Analysis Model.

3.2 Analysis of Development Period and overall Rate of Return from Small Hydro Financial Analysis Model.

3.3 Cost Flows from Operational Period from Small Hydro.

3.4 Net Present Values of Costs and Revenue Items over the life of a typical Small Hydro Project.

3.5 Financial Feasibility of On-grid Power.

4.1 Effect on Cost Flows of Eliminating School Tax and Water Rent.

4.2 Financial Feasibility of Small Hydro Power for Alternative Policies.

4.3 Impact of Eliminating Water Rent and/or School Tax.

Appendix 1 Economic Cost of Power for all sites costing less than 10 cents per kW.h
(sorted according to cost)
(sorted alphabetically)

Appendix 2 Small Hydro Power Cumulative Characteristics vs Equivalent non-inflated Cost per Kilowatt Hour
(all sites)
(on-grid sites)

Appendix 3
1. Power Cost for Site C assuming Sale of all Power.
2. Power Cost for Site C assuming Sale of Power for Domestic Demand only.

Appendix 5
1. Comparison of Actual Energy Requirements with probable forecast of Total Gross Requirements. (Percent)
2. Electricity Requirements Balance (BC Hydro System only).

# 1. INTRODUCTION

## 1.1 BACKGROUND

In order to assess the small hydro power resource in the provincial system, two complementary studies were commissioned by the Ministry of Energy, Mines and Petroleum Resources, and completed in July 1983.

The primary study was entitled, **Small Hydro Power Resource in the Provincial System, Technology and Resource Assessment**. (Reference 1). The status of the technology of small hydro power was reviewed and an inventory of 665 sites in British Columbia was provided. It is referred to in this report as the **Resource Assessment**.

Based on the limited data base of the study, these power sites appear to be technically feasible either to develop and connect to the integrated transmission system (referred to as on-grid sites) or to provide a supplementary power source in areas presently served by diesel generation (referred to as off-grid sites).

This study builds on the technical base provided in the companion report and assesses the economic feasibility and financial viability of the inventory of potential power developments.

BC Hydro presently operates eight hydro facilities with an installed capacity of less than 20 MW. However, the economies of scale provided by large hydro power schemes has tended to make further development of small hydro power too costly. Now the relative cost of constructing such generating facilities is rising as many of the low cost, environmentally acceptable sites have already been developed.

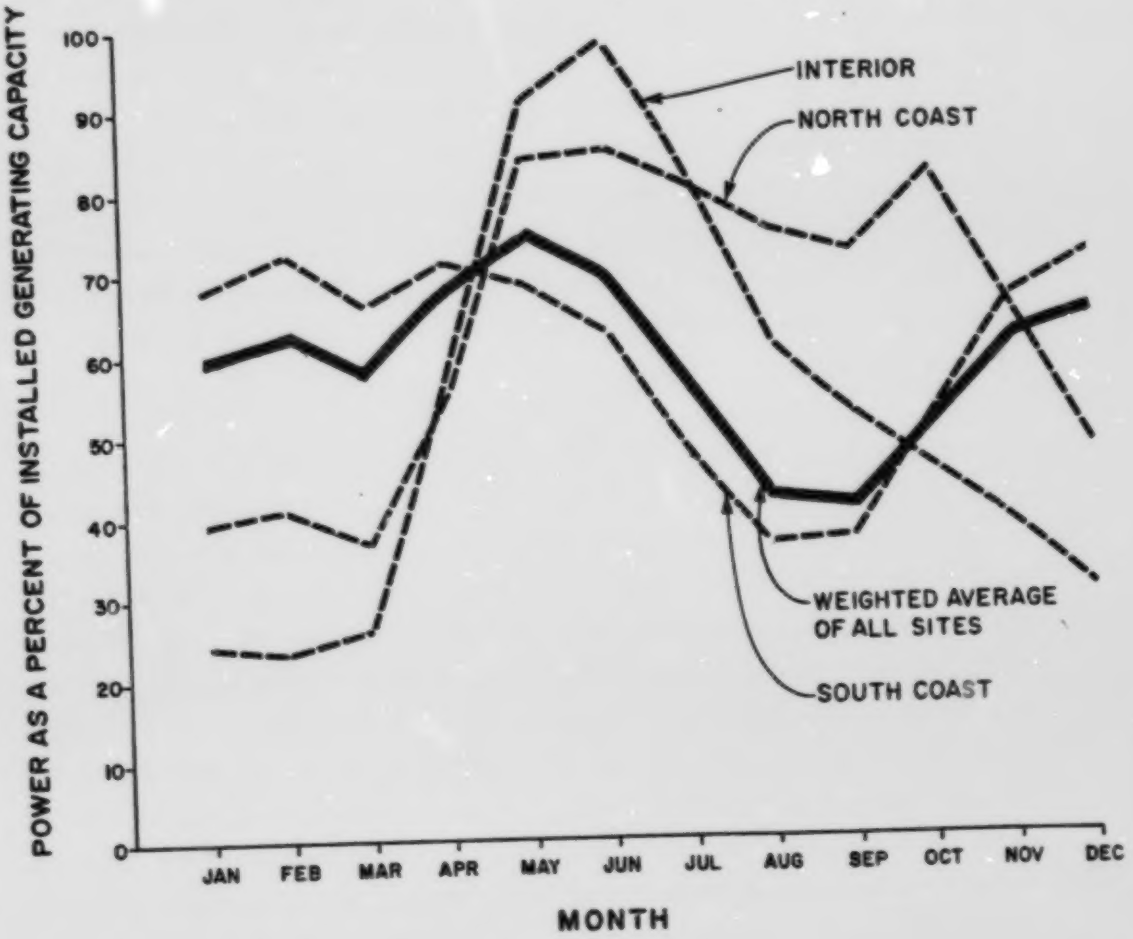
In contrast, the on-grid potential of small hydro power has been largely ignored and many of the relatively low cost sites are undeveloped. Hence the cost advantage of large scale hydro development has diminished relative to small hydro power in recent years. This, in part, explains the re-emergence of interest in the small hydro power resource.

The increasing awareness of the potential of the small hydro power resource is not confined to British Columbia. For example, the federal government is examining the potential for small hydro power to reduce the dependence of remote communities on imported oil (Reference 2/Reference 12). Further, in the United States, with the passage of the National Energy Act of 1978, small hydro power development (as well as a number of other alternative energy systems) became more attractive. In California alone, over 450 applications have been submitted to develop small hydro power (Reference 3).

## 1.2 OVERVIEW OF THE SMALL HYDRO POWER RESOURCE

The **Resource Assessment** identified sites that were within a reasonable distance of existing transmission lines or near diesel generating areas. With the aid of small scale contour maps and streamflow information, basins were analyzed and, if appropriate, projects conceived that had a capacity of less than 20 MW. This capacity limit was imposed so that the sites would fall within the streamlined application and approval process of the BC Utilities Commission. Within this capacity constraint, the plants were sized to be at full generation capacity for the mean annual flow of the particular stream. Most projects are run of the river plants. That is, the energy produced from a run of the river plant will fluctuate with streamflow. This seasonal variation in energy production is shown in Figure 1.1 for selected sites on the south coast, north coast and interior sites.

The energy production profiles are weighted averages of all sites in each region identified in the **Resource Assessment**. The production profiles result from the seasonal flow patterns in each region. In the south coast region, energy production averages in excess of 60 percent of installed capacity for seven months of the year. Energy production is greatest during the winter months when much of the precipitation falls as rain. This may be particularly important since electrical demand is generally the greatest during the winter season. Production falls to about 40 percent of installed capacity during the summer months when precipitation is at its annual low.



VARIATION OF SMALL HYDRO POWER CONTRIBUTION

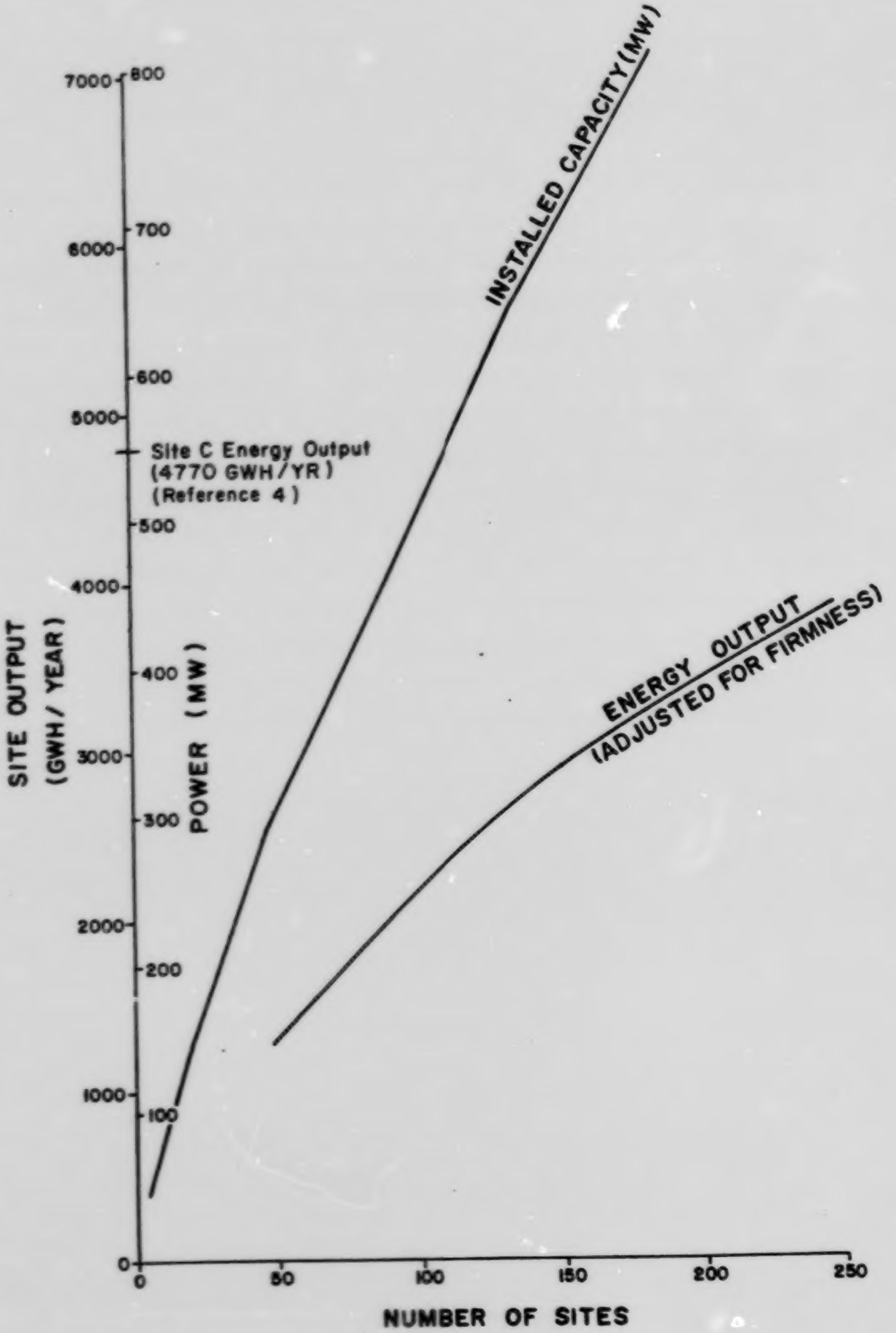
Note: Generator installed to use mean annual flow, run of river.

**MEAN MONTHLY POWER OUTPUT AS A PERCENT OF INSTALLED GENERATING CAPABILITY vs. MONTH OF YEAR**

FIGURE 1.1

The production profiles of the north coast and interior regions are different because a greater proportion of the precipitation falls as snow, which in turn effects stream flow patterns. In contrast to the south coast sites, the lowest production rates are in the winter months for these two regions. The impact of spring runoff is reflected in the higher production rates which reach maximum values during June and July. The influence of the spring freshet is dominant in the interior, where many of the sites reach production capacity during the same month (June). The north coast sites attain a second maximum during the late fall when the precipitation has not yet turned to snow. The weighted average production rates follow the general pattern of the south coast because about 70 percent of the technically feasible sites identified in the **Resource Assessment** are located in this region. The weighted average of all sites shows less variance than that of the individual regions, which is partly a result of the complementary regional production profiles.

From Figure 1.1 it is clear that the plants will be operating at less than full capacity during significant portions of the year. The **Resource Assessment** defined a 'firmness factor', which is the expected annual energy production of a plant divided by maximum possible production (installed capacity in kilowatts x 8760 hrs/year), and this factor was estimated for each site. The firmness factor would be numerically equal to the load factor for sites supplying power to an unlimited demand such as might be the case for supply to the integrated grid. The system load factor may be substituted for the firmness factor for off-grid sites with limited load when the plant output is limited by lack of water or lack of power demand. Note that the system load factor for a site will be less than or equal to the firmness factor because at times more power may be available than is needed. In general, the firmness factor is higher for coastal sites (average value of 0.6) than for the interior sites (average value of 0.5). Small hydro energy production from each site has been adjusted for firmness and it is on this supply of energy that the economic and financial analysis is conducted. The relationship between energy output adjusted for firmness and total installed capacity is illustrated in Figure 1.2.



QUANTITY OF SMALL HYDRO POWER
vs. NUMBER OF SITES

FIGURE I.2

3270

## 1.3 STUDY ORGANIZATION

This study builds on the cost data developed in the **Resource Assessment** in order to determine the economic feasibility and financial viability of the resource. For most of the 665 sites identified, the **Resource Assessment** provides capital and operating cost estimates. Although technically feasible, the cost of developing the energy potential of many of these sites may exceed the cost of energy from an alternative source. That is, particular sites may not be economically feasible. The economic value, as well as a consideration of the planning flexibility offered by the small hydro power resource is addressed in Section 2. It may be the case however, that a site is economically feasible from the social perspective, but the financial returns to a private developer would not justify the investment. In Section 3 the minimum financial rewards necessary to develop the economic potential of the resource are considered. In Section 4, the effects of existing and potential public policies for promoting development of the resource are considered. In Section 5 the Conclusions and Recommendations of the economic and financial assessment are presented.

## 2. ECONOMIC ASSESSMENT OF THE SMALL HYDRO POWER RESOURCE

The objective of this component of the study is to assess the economic feasibility of 612 (1) small hydro power sites identified in the Resource Assessment. Economic feasibility is defined in terms of the cost of developing a particular site relative to the cost of developing the next best energy source. The next best energy source (for on-grid applications) was taken to be one of several major hydro power projects under study by BC Hydro. A small hydro power site is deemed to be economically feasible if its average cost per unit of output is less than or equal to the equivalent cost from the next major hydro power project developed in British Columbia.

In Section 2.1, the categories of costs affecting the small hydro power resource are discussed and the total costs of developing the resource are presented. In Section 2.2, the cost of meeting future electricity requirements through delaying or avoiding the need for the construction of major projects is estimated and compared to the cost of developing the potential on-grid small hydro power sites. The economic feasibility of off-grid sites is presented in Section 2.4 following a review of sensitivity analysis in Section 2.3.

Before beginning the detailed discussion, those features distinguishing the economic and financial analysis should be noted. The economic analysis adopts a more broadly defined referrant group than the financial analysis and uses the social opportunity cost concept instead of market prices; whereas the financial analysis proceeds from the perspective of the private investor, the economic analysis is from the perspective of the society. The social opportunity cost of an economic resource is its value in its next best alternative use, which may or may not correspond to the prevailing market prices. For the most part, the analysis takes market prices as an adequate measure of the social opportunity cost of developing the resource. The one important exception is the value of electricity, which is estimated as the sum of the costs of production rather than the regulated prices under which electricity is actually sold.

---

(1) Of the 665 sites included in the **Resource Assessment**, there was not enough detailed information available on 53 sites for economic evaluation. The remaining 612 form the basis for the economic assessment described in this Section of the report.

## 2.1 COSTS

Project costs appropriate to the economic analysis are the consumption of economic resources (materials, goods and services) over the life of the project. Costs that are relevant in the financial analysis but do not represent a use of resources, such as depreciation and taxes, are specifically excluded. The opportunity costs of the resources are taken at the respective 1982 prices. The analysis excludes inflation and further, it is assumed that capital and operating costs will remain constant in real terms over the forecast period. Inflation, which is a rise in the general price level, does not affect relative prices. It can be excluded from the economic analysis without affecting the results. Also included in the economic assessment are costs not necessarily borne by the developer but which are nevertheless incurred by the provincial society. Examples might include affects on downstream users, and impacts on other watershed users. Effects of this nature are site specific, hence can only be assessed qualitatively at this level of study.

The major cost categories are considered below before the cost information on the 612 sites evaluated is presented.

### Capital Costs

Capital costs include the expenditures for plant and equipment, transmission line and access road. The costs were taken directly from the **Resource Assessment**. The estimates include an escalation factor that takes account of the generally higher construction costs of remote sites. To simplify the analysis, each site was considered as a stand alone project whereas capital cost savings could be realized if several sites were developed together thus sharing the transmission line and the access road.

The penstock is typically the single most costly capital item of a small hydro power facility, making up approximately 20 - 60 percent of the installed plant and equipment costs. Plant capacity was sized to the estimated average annual flow of the stream. The access road cost was estimated as a function of length and the size of plant. The cost of the transmission line depends on length as well as the appropriate rating of the line (12 kV to 138 kV lines). Consistent with the level of detail available in the **Resource Assessment**, each project was optimized in terms of minimizing plant costs while meeting particular performance and reliability criteria.

A contingency factor of 30 percent was included. The costs of land, rights-of-way, and the interconnection facility (for on-grid sites) were not specifically included. However, these costs are expected to be relatively modest compared to the cost of other components, and are, for the purposes of this study, included in the contingency category.

Capital cost analysis methods used in the **Resource Assessment** are described in more detail in Appendix 4.

### Operation and Maintenance

The operation and maintenance costs depend on the size and operating characteristics of the plant as well as the operation requirements of the owner/operator, and the utility (on-grid). The estimates included here assume a relatively high degree of automation; also that several sites would be developed and operated simultaneously. Operation and maintenance costs were estimated at 1.2 percent of the installed capital costs and remaining constant (net of inflation) over the project life (50 years). If a full time operator were required on-site, then the annual charge would be in the order of 2 - 4 percent of installed capital cost. It should be noted that because taxes (corporate income tax, property tax, etc) and water rental fees do not represent a draw on real economic resources they were not included in the operating expenses.

### Transmission and Downtime Losses

Included in this category are the power losses in transmission which depend on line length and capacity, and annual energy generation reductions due to periodic plant outages and closures for maintenance. These losses were anticipated to be in the order of 10 percent of gross annual production. For the on-grid sites, this is the net energy assumed to be delivered to the grid.

### Non-Quantifiable Costs

The effect of the typical run-of-the-river small hydro project on other watershed uses is expected to be minimal. The nature of the facility requires the penstock to be located on a relatively steep gradient where stream flow velocity typically exceeds that favourable for fish habitat. Valuable scenic attributes of a particular watershed may be reduced during periods of low flow if the stream is largely dewatered between the penstock and tailrace.

More significant impacts may arise from interdependencies with forest harvesting and related activities. Road building and logging may increase the debris and sediment load in the stream, thereby affecting facility operations such as increased wear on turbines and penstock. In addition, the post-logging discharge of the stream may be altered (increased peak flows and reduced low flows compared to pre-logging discharge) which could decrease the total energy production of the plant. These effects can be reduced by altering forest activities (changing road alignments, green strips beside the stream, adjusting the cutting plan, etc) which would typically increase forestry costs. In practice, the conflict would likely be resolved with reference to current logging practices and through negotiations between the two parties. Nevertheless, the incremental costs arising from the interdependency is acknowledged in the social benefit-cost framework regardless of which party bears the costs. At this level of study, sufficient information was not available to estimate the magnitude of this cost.

### Total Costs

The total quantifiable cost of small hydro power is the present value sum of the capital and operating costs. Future annual costs are converted into 1982 present value equivalents using an 8 percent real discount rate (the recommended rate according to the revised Provincial Benefit-Cost Guidelines).

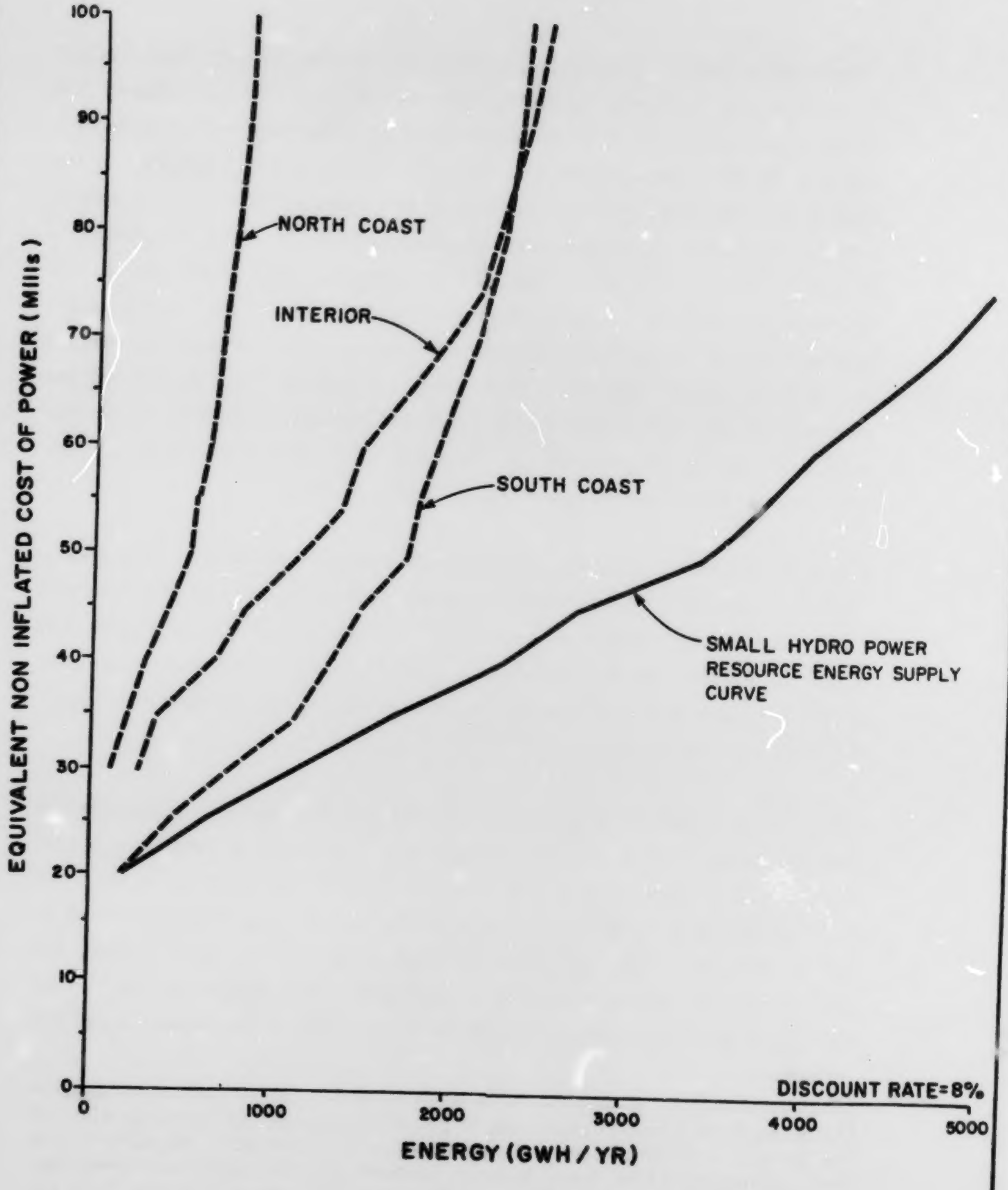
To provide a clearer understanding of the costs of developing the resource, and to facilitate the economic feasibility analysis, the equivalent non-inflated cost of power was computed for each site in each of three regions.(1) (Appendix 1 contains the total cost per kW.h computed for each site and Appendix 1 of the **Resource Assessment** contains a printout of site costs and site characteristics). The cost varies significantly among sites ranging from 20 to 400 mills/kW.h. In Figure 2.1, firm energy supply has been arranged from the lowest cost to the highest cost sites. The south coast region contains many of the low cost sites, followed by the interior and north coast regions. The regional curves are summed horizontally (ie. for a given cost, the energy from the regions are summed) to yield the energy supply curve for the total resource. Since the energy production is adjusted for firmness, the supply of energy at the respective costs represents potentially available energy.

Figure 2.1 forms the basis for the economic feasibility assessment described in Section 2.2 and Section 2.4 where the average cost of on-grid and off-grid small hydro power applications is arrayed in the same manner as Figure 2.1. Figure 2.2 presents the regional distribution of the less costly sites. Note that a very large proportion of the less costly sites are located on Vancouver Island and the Lower Mainland.

Figure 2.1 summarizes a great deal of useful information. It represents the long run supply of small hydro power capacity. That is, for a given average cost of energy of an alternative source, Figure 2.1 provides an estimate of the small hydro power capacity that would be less costly to develop if unconstrained by institutional, financial, and other considerations. In the next section, the cost of alternative energy sources is estimated and compared to the cost of developing small hydro power in order to define the economic feasibility of the resource.

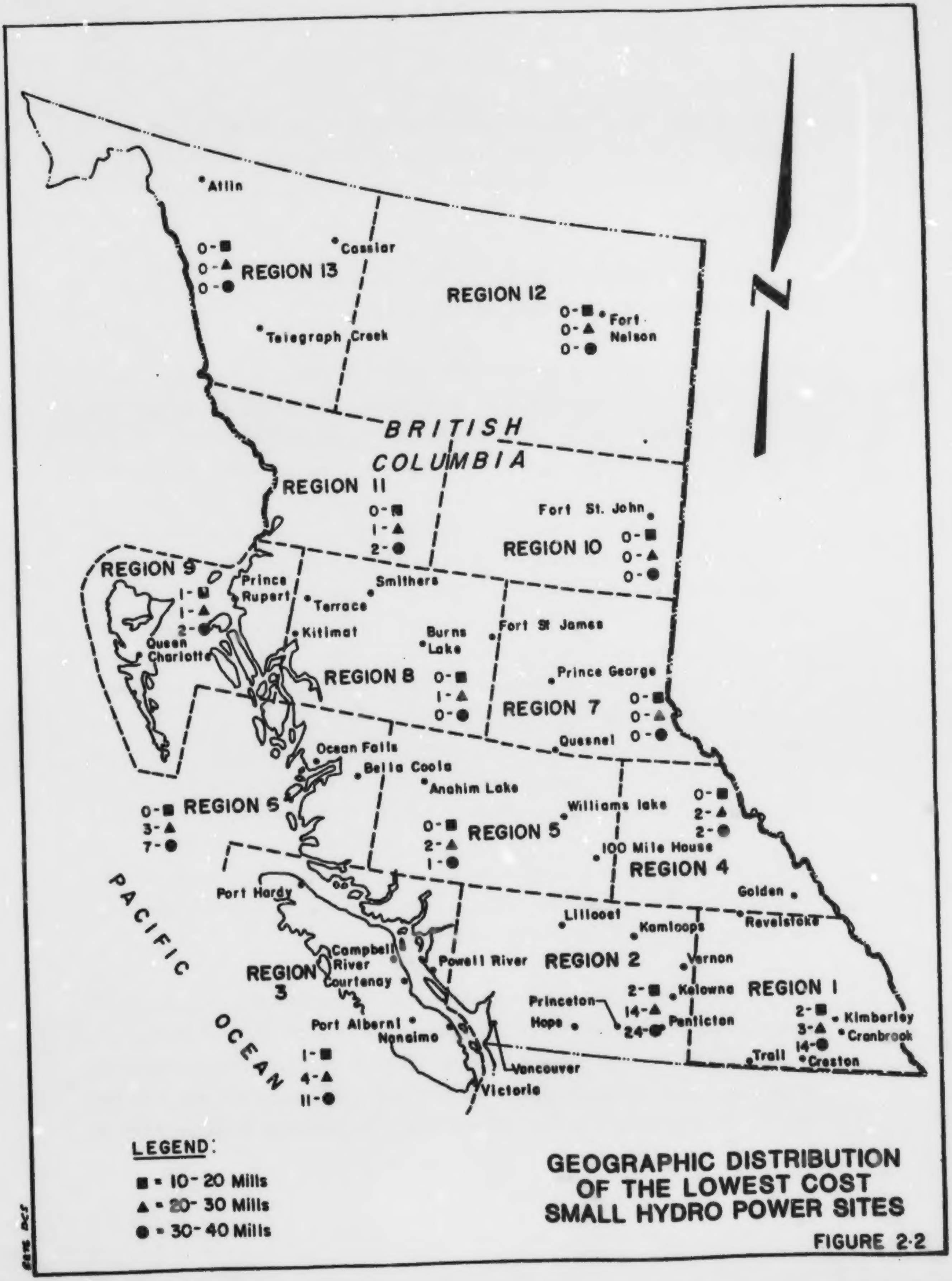
---

(1) The equivalent non-inflated cost of power was computed as the quotient of the present value total cost and present value net electricity production. The cost estimates differ from those presented in the Resource Assessment because: (a) operation and maintenance costs and transmission line costs are included; (b) allowance is made for electricity losses due to transmission losses and periodic shutdown; (c) an 8% discount rate and a 50 year project life was assumed rather than a 5% discount rate and an infinite project life as adopted in the Resource Assessment.



SMALL HYDRO POWER RESOURCE
INCREMENTAL ENERGY CAPABILITY
vs. INCREMENTAL COST OF POWER

FIGURE 2.1


N
BRITISH COLUMBIA
PACIFIC OCEAN
REGION 13
0-■
0-▲
0-●
Atlin
Cassiar
Telegraph Creek
REGION 12
0-■
0-▲
0-●
Fort Nelson
REGION 11
0-■
1-▲
2-●
REGION 10
0-■
0-▲
0-●
Fort St. John
REGION 9
1-■
1-▲
2-●
Queen Charlotte
Prince Rupert
Terrace
Kitimat
Smithers
REGION 8
0-■
1-▲
0-●
Burns Lake
Fort St James
Prince George
REGION 7
0-■
0-▲
0-●
Quesnel
Ocean Falls
Bella Coola
Anahim Lake
REGION 6
0-■
3-▲
7-●
REGION 5
0-■
2-▲
1-●
Williams lake
100 Mile House
REGION 4
0-■
2-▲
2-●
Golden
Revelstoke
Port Hardy
Campbell River
Courtenay
REGION 3
1-■
4-▲
11-●
Port Alberni
Nanaimo
Powell River
Vancouver
Victoria
Lillooet
Kamloops
REGION 2
2-■
14-▲
24-●
Vernon
Kelowna
Princeton
Hope
Penticton
REGION 1
2-■
3-▲
14-●
Kimberley
Cranbrook
Trail
Creston
LEGEND:
■ = 10-20 Mills
▲ = 20-30 Mills
● = 30-40 Mills

GEOGRAPHIC DISTRIBUTION OF THE LOWEST COST SMALL HYDRO POWER SITES

FIGURE 2-2

Notwithstanding the conclusions reached in Section 2.2, Figure 2.1 provides a simple and comprehensive means for assessing the economic feasibility of the resource in light of the changing energy requirements and opportunities in British Columbia.

## 2.2 THE ECONOMIC BENEFITS OF SMALL HYDRO POWER DEVELOPMENT AND ECONOMIC FEASIBILITY

As noted earlier in Section 2, the economic value of small hydro power output is the cost (saved) of an alternative energy source. This value will be different depending on the perspective of the developer as well as the characteristics of the output. For example, the value of small hydro power to industry, or to a community served by a diesel plant, is the cost savings of displacing purchased electricity (industry) or fuel cost savings (community). For the private developer, the value of small hydro power output is its selling price. This latter perspective is assessed in Section 3. From the broader provincial point of view, the value of small hydro power output is the cost savings realized from displacing the next best alternative cost energy source. We have assessed the economic value of the small hydro power resource from the latter perspective.

The value of the energy output is also related to how "dependable" it is. That is, whether the energy is always available when it is required. Output of this nature has a "capacity value". If, on the other hand, the output is available independent of system requirements, then the value corresponds to the most costly fuel displaced at the time the output is available. This is termed the "energy value". Because of the nature of the small hydro power resource, only the energy value was attributed to the output.

A small hydro power development is defined to be economically feasible if the present value of the output exceeds the present value of all costs of production. In Section 2.1 the total present value of all costs of production is presented without regard to either on-grid or off-grid potential. Since the value of the output differs between the two applications, this distinction must be made to establish economic feasibility. In this section the economic feasibility of on-grid applications is considered. In Section 2.4, the off-grid assessment is considered.

The average value of on-grid energy will be estimated first in terms of mills per kW.h. This value is then compared to the costs of developing the sites that could possibly be grid-connected to determine economic feasibility. A similar procedure is followed in assessing the economic feasibility of off-grid applications.

### On-Grid Small Hydro Power Assessment

The **Resource Assessment** identified 521 sites that could possibly serve the integrated grid and which had sufficient information for cost analysis. The average cost of the sites ranges from 22 mills to 325 mills per kW.h (Figure 2.3); 206 of these sites are on the south coastal area of the mainland and Vancouver Island; 53 are located in the Bella Coola area and the north coast; and 262 are located in the interior. Total potential installed capacity is estimated at 1,217 MW although only part of this could be considered cost competitive relative to large scale hydro power alternatives.

The economic value of energy output to the integrated electrical grid is the equivalent cost of energy displaced from the highest cost source in the system. In a "mixed" hydro/thermal system, the savings would be the fossil fuel cost saving from thermal generation. However, the provincial system is predominantly a hydro power system.(1) Once a hydro power plant is in place, the annual operating costs are low. This value is well below the average cost of production from even the least costly small hydro power site. That is, the development of small hydro power to displace energy produced from existing facilities is probably not economically feasible. Similarly, the capital cost of the nearly completed Revelstoke Project is "committed", so that the value of displacing incremental energy over the near term is also very low.

---

(1) The Burrard Thermal Plant is operated during peak periods and critical low flow years. Although energy from this facility might be the highest cost, potential output from small hydro power does not have the same performance characteristics, hence it is considered that one is not a substitute for the other.

With the commissioning of the Revelstoke Project (in 1984), the firm generating capacity of the B C Hydro system will be approximately 10,190,622 kW. This capacity is expected to be sufficient to meet domestic firm energy requirements until 1991 and perhaps later, depending on the load growth forecast considered.(1)

At some point in time, however, system expansions will be required to meet the growth in provincial energy requirements. Since the capital expenditures of these future projects are not committed (that is still an avoidable cost), it is appropriate to express the value of small hydro power output as the cost of production from a future conventional hydro power plant.

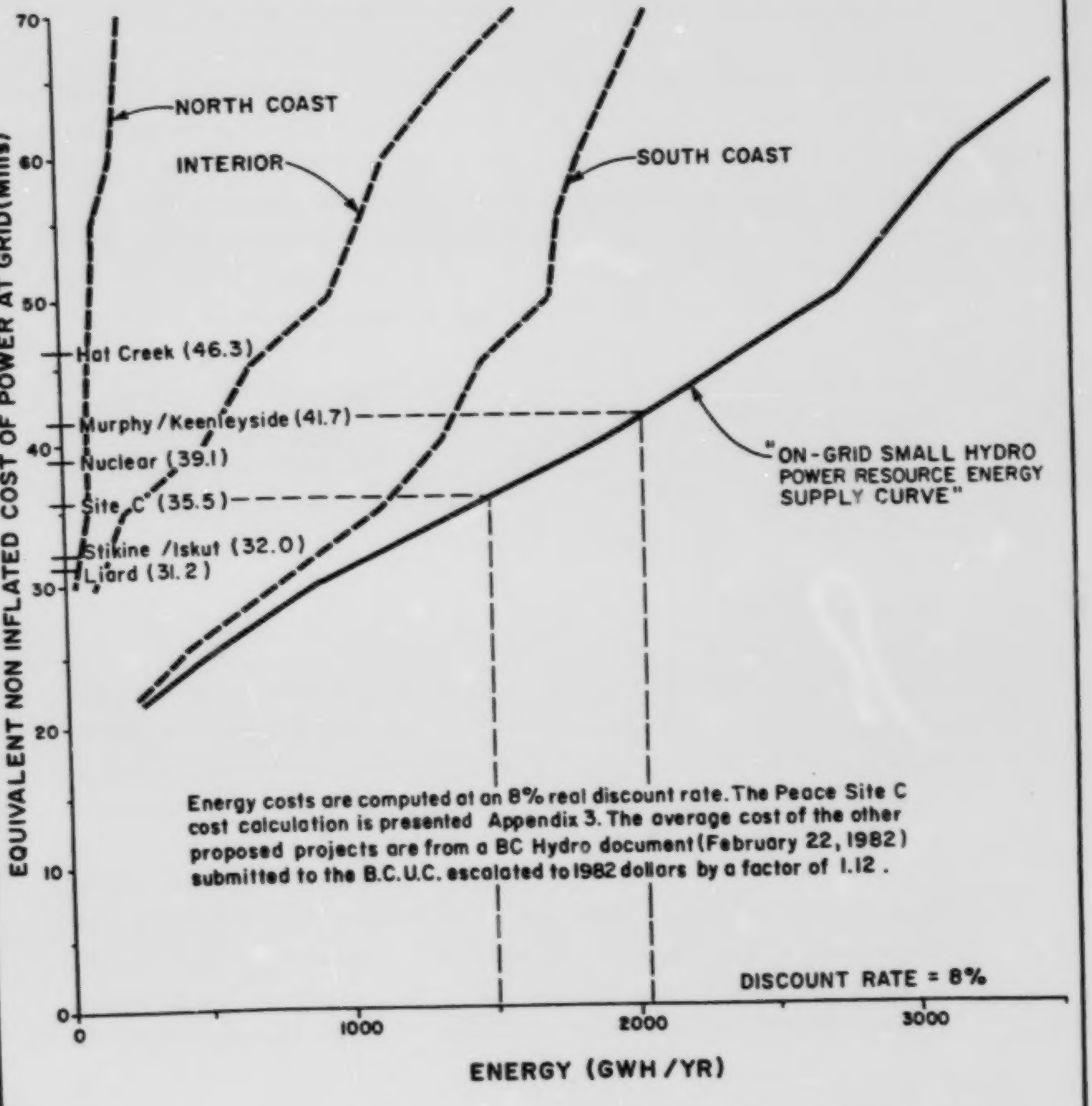
Although electricity is produced by Alcan, MacMillan Bloedel, West Kootenay Power and Light, and B C Hydro, future electricity requirements will likely be primarily met by additions to the B C Hydro system. B C Hydro has a series of hydro power facilities under study to meet provincial energy requirements over the next twenty years (Reference 4). The Peace Site C project is the most advanced in terms of planning with a tentative in-service date of February 1991.(2) Other projects include the Murphy/Keenleyside, Liard, Iskut Canyon, and the Stikine. The average energy costs from each of these projects, as well as several others, are presented in Figure 2.3 along with the cost of developing the on-grid small hydro power sites in the three regions.

The economically feasible small hydro power sites are defined as those of average energy costs that are less than or equal to the average cost of the alternative project. With regard to Peace Site C, there are 54 sites with an installed capacity of 300 MW that can provide energy at lower costs. Compared to the Murphy Creek/Keenleyside Project, there are 84 feasible sites with an installed capacity of 430 MW. According to the **Resource Assessment**, the 54 sites would provide 1,370 GW.h/year of energy which represents 2.3 years load

---

(1) See Appendix 5 for a discussion of assumptions regarding B C Hydro system and power demand forecasts.

(2) B C Hydro has applied to the BC Government for an Energy Project Certificate. The decision regarding the terms and conditions of a certificate was still under consideration when this study was prepared.



Energy costs are computed at an 8% real discount rate. The Peace Site C cost calculation is presented Appendix 3. The average cost of the other proposed projects are from a BC Hydro document (February 22, 1982) submitted to the B.C.U.C. escalated to 1982 dollars by a factor of 1.12.

ON-GRID SMALL HYDRO POWER
INCREMENTAL ENERGY CAPABILITY
vs. INCREMENTAL COST OF POWER
(At point of grid connection)

FIGURE 2.3

5276

growth assuming the most recently available load forecast by the Ministry of Energy, Mines and Petroleum Resources (MEMPR) (Reference 6). The 84 sites would provide 1,970 GW.h/year and contribute 3.0 years of load growth.

There are two other aspects of small hydro power that may affect its economic feasibility. Firstly, there may be lower transmission losses associated with small hydro power production compared to conventional hydro power because small hydro power feeds into lower voltage lines on the grid, which tend to be closer to the consumer. Note that many of the economically feasible small hydro power sites are located in the south coast regions which contain the largest population centres. Figure 2.3 compared the average costs of conventional hydro power at the **plant site** to small hydro power at the grid **connection**. In the following analysis, the costs of energy will be compared at a common point which is taken to be a **residential customer.**(1) Secondly, the incremental nature of small hydro power offers an economic savings as well as planning flexibility. These two aspects of the small hydro power resource are considered in the following sections.

## Transmission Losses

There are a number of factors which interact to determine the proportion of generated energy lost on route to the final user. For the entire BC Hydro system, these losses are in the order of 10 percent of the generated energy. However, losses attributed to serving customers at particular voltage levels are much higher than the system average. Incremental loss multipliers, which represent average values for the BC Hydro transmission system are presented in Table 2.1. The secondary voltage level refers to residential and general service (single phase 60 hertz, at secondary potential). In order to deliver 1 kW.h of energy to the final user, 1.4279 kW.h must be produced at the generating station (assuming average operation at 75 percent of peak capacity and initial transmission at 500 kV). In contrast, many of the small hydro power sites would be connected into the grid at 25 kV (primary voltage). Small hydro power cannot economically connect into a transmission line greater than 138 kV because the size of the plant (that is less than 20 MW) does not justify the expense. Hence, a greater proportion of the energy produced from a small hydro power site may be available when serving a residential customer.

---

(1) The lower voltage delivery points on the grid tend to be associated with higher losses because of the lower efficiency of transmission at lower voltages. The assumption of delivery to a residential customer therefore is a case where losses are highest.

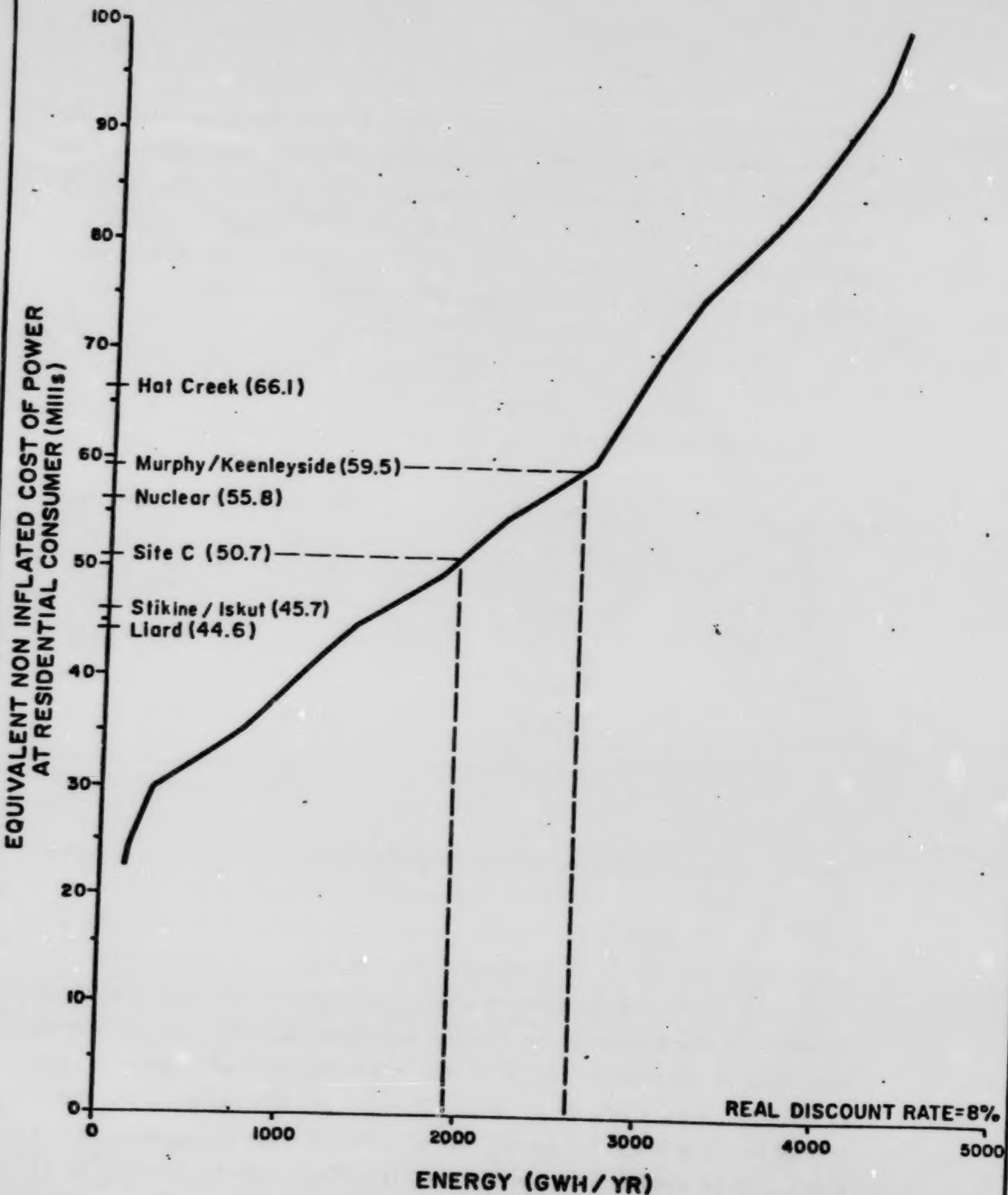
TABLE 2.1

CUMULATIVE INCREMENTAL ENERGY LOSS MULTIPLIERS

| Voltage (kV) | 100% Peak | 75% Peak | 50% Peak |
|---|---|---|---|
| 500 | 1.0947 | 1.0747 | 1.0447 |
| 230 | 1.0933 | 1.0752 | 1.0490 |
| 138 | 1.1233 | 1.1087 | 1.0999 |
| 60 | 1.1128 | 1.0868 | 1.0660 |
| Primary | 1.3458 | 1.2199 | 1.1262 |
| Secondary | 1.6564 | 1.4279 | 1.2520 |

(Source B C Hydro - Reference 5)

The cost of energy from proposed conventional projects and small hydro power plants delivered to the final user at a secondary voltage level is presented in Figure 2.4. The generation costs of the conventional hydro power plants are adjusted by the 500 kV incremental loss multiplier to account for the transmission losses and the costs of small hydro power are adjusted by a factor to allow for losses in the primary and/or secondary network. When economic feasibility is defined in terms of the delivered cost of energy to the residential/general user, up to 80 small hydro power sites could be viable related to Peace Site C for a capability of 1,890 GW.h per year, and up to 123 sites could be viable related to Murphy Creek/Keenlyside for a capability of 2,570 GW.h per year.



ON-GRID SMALL HYDRO POWER
INCREMENTAL ENERGY CAPABILITY
vs. INCREMENTAL COST OF POWER
(At point of delivery to consumer)

FIGURE 2·4

It should be noted that in certain circumstances the methodology adopted here may overstate the potential savings in transmission losses possible for small hydro power development. This is because the potential savings not only depend on the voltage and length of the transmission line to which the small hydro power plant is being connected, but also on the total requirements of the users served. If it is the case that small hydro power production exceeds the requirements of downline users, then it would be necessary to transfer power back into the main grid. The small hydro power transmission loss savings would be much lower in this circumstance. Studies in the United States (Reference 8) have shown that these effects are site specific and have concluded that they should not be a consideration in setting power rates. Although the magnitude of the potential savings should be evaluated further in future studies, it may be the case that the lack of downline demand is not particularly significant in British Columbia. This is because many of the best small hydro power sites are in the Lower Mainland and Vancouver Island, near low voltage portions of the grid. In most cases there is ample downline demand to absorb all the power produced.

### Average Costs of Small Hydro Power

If small hydro power were developed up to a long term marginal cost less than or equal to the economic cost of power from Peace Site C (35.5 mills), the average cost of the approximately 1370 GW.h per year of energy would be about 27 mills. This means that this much energy could be available at an average cost of about 8.5 mills less than that from Peace Site C.

In present value terms the value of substituting this low cost small hydro power for 2.3 years of operation of Peace Site C (around 1990 to 1992) is approximately $13 million.

### Phased Small Hydro Power Development

The advantage of small hydro power relative to conventional projects in terms of scheduling new capacity to match load growth has not been captured in the analysis thus far. During periods of relatively modest load growth, limited export opportunities and conventional projects of large capacity, the number of economically feasible small hydro power sites increases because the economic cost of carrying large increments of unused capacity in the large hydro power facilities is significant.(1)

This is a complex area of energy planning that cannot be adequately covered in this study. Our purpose here is to illustrate the flexibility of small hydro power in meeting additional load growth, and the nature of the economic cost savings that could be realized. A more comprehensive approach would include an assessment of the BC Hydro generation plan to include the phased development of small hydro power and the cost of such a modified generation plan compared to the current one.

To illustrate the potential advantages of small hydro power development, a phased development program was compared to the construction of the Peace Site C plant to meet forecasted load growth (Figure 2.5). The incremental nature of the small hydro power resource is evident in this illustration as capacity is added to match expected load growth. The more efficient utilization of invested capital (assuming that a large proportion of the capacity of the larger project is not initially utilized) is a major potential cost saving. Potential cost savings also stem from two other sources. Some small hydro power capacity is less costly to develop than conventional hydro power (Figure 2.3 and Figure 2.4). Also, the major capital expenditures for small hydro power need not be committed until one to two years in advance of the in-service date. Peace Site C, on the other hand, requires a 9 year construction

---

(1) A number of recent studies indicate that the demand for electricity exports on an interruptible basis will be limited (Reference 7). For example, the average cost of Site C was estimated on the assumption that its full energy production will be demanded as soon as it is technically available. If, on the other hand, production were constrained by the growth in provincial energy requirements, then the average cost would be 41.4 mills/kW.h (assuming MEMPR electricity forecasts). The difference in average cost of 5.9 mills is the incremental cost of carrying the unused capacity of the project until domestic requirements grow to the point it is fully utilized. This could be reduced if there were a demand for exported power at that time.

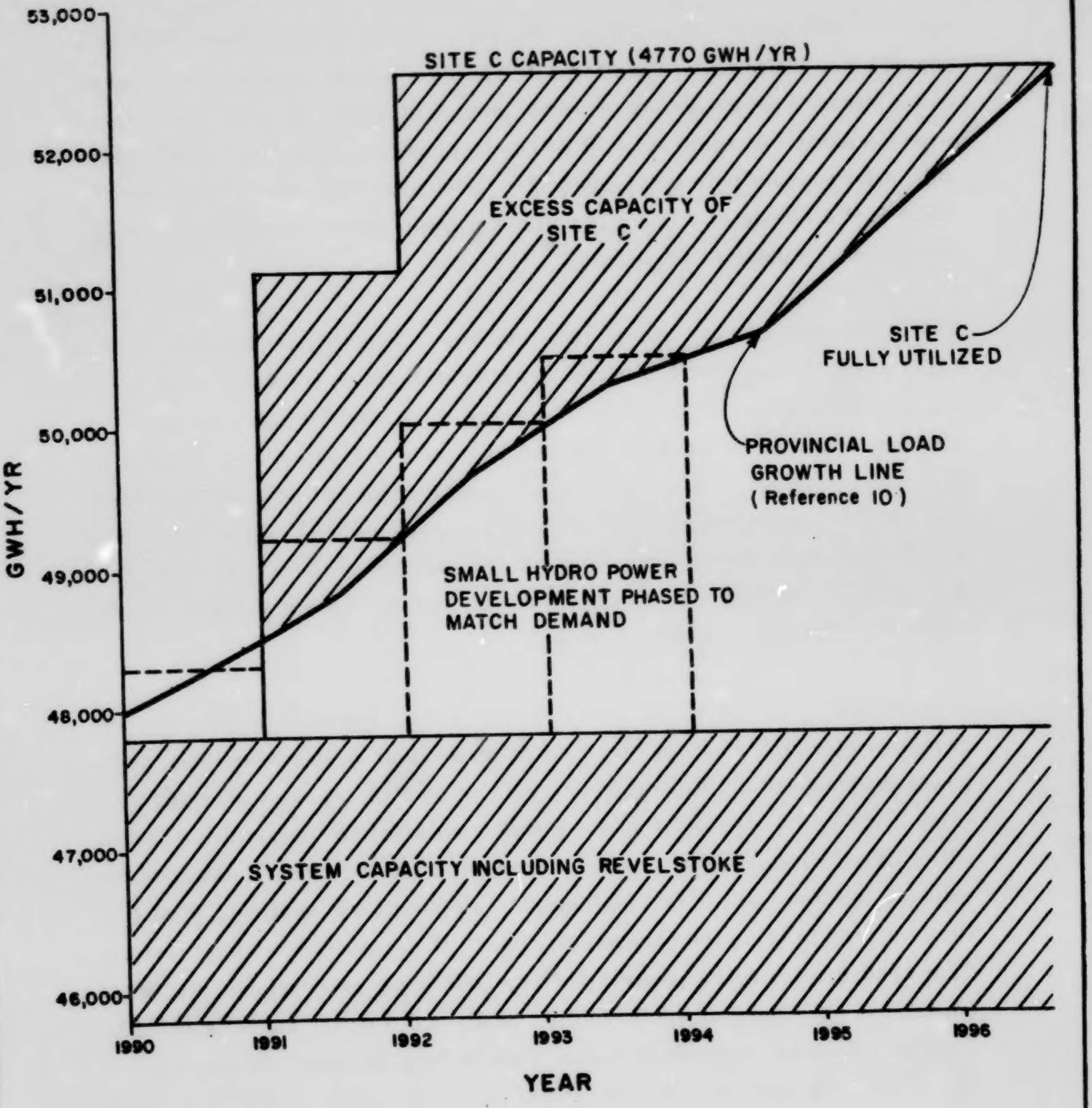


ILLUSTRATION OF PHASED SMALL HYDRO POWER DEVELOPMENT COMPARED TO SITE C IN MEETING PROJECTED ENERGY REQUIREMENT

FIGURE 2.5

3876 DCS

period. Therefore the Peace Site C Project could be deferred if preceded by a phased small hydro power development. However, as the less costly small hydro power sites are developed, the incremental cost of additional small hydro power sites increases. At some point, it will be less costly to meet future load growth with a large scale power development. Given the load growth projection by MEMPR (Reference 6), a phased small hydro power development could defer the conventional project 2 to 3 years.

The dollar value of cost savings resulting from a hypothetical delay of a large hydro power project that has excess capacity depends on the value of power in the export market. In the case of Peace Site C and assuming no export is possible, the present value of the approximately 2.3 year delay possible by developing feasible small hydro power, could be about $23 million on a present value basis. This, combined with the potential saving of $13 million due to less costly small hydro power, indicates a possible net present value benefit of about $36 million if the feasible small hydro power resource were developed between 1990 to 1993 in advance of Peace Site C.

This analysis is presented to illustrate the flexibility implicit in the development of the small hydro power resource relative to conventional hydro power developments. Projecting future requirements is always uncertain, but small hydro power may offer energy planners an effective response for dealing with this uncertainty. This flexibility arises from the incremental nature of the resource (a large number of small capacity sites) and the relatively short lead time required to bring the capacity on line. Although these beneficial features have been demonstrated relative to large hydro power developments, these advantages have general applicability. Small hydro power capacity could be developed to meet unforeseen circumstances (e.g. to assist in meeting the electricity requirements of new industry) or to serve attractive market opportunities well in advance of conventional hydro power developments. Even during periods of rapid load growth, when small hydro power would have a limited effect on the timing of large projects, the average cost of a significant number of sites is below the cost of a new conventional hydro power development, and could be brought into service much sooner.

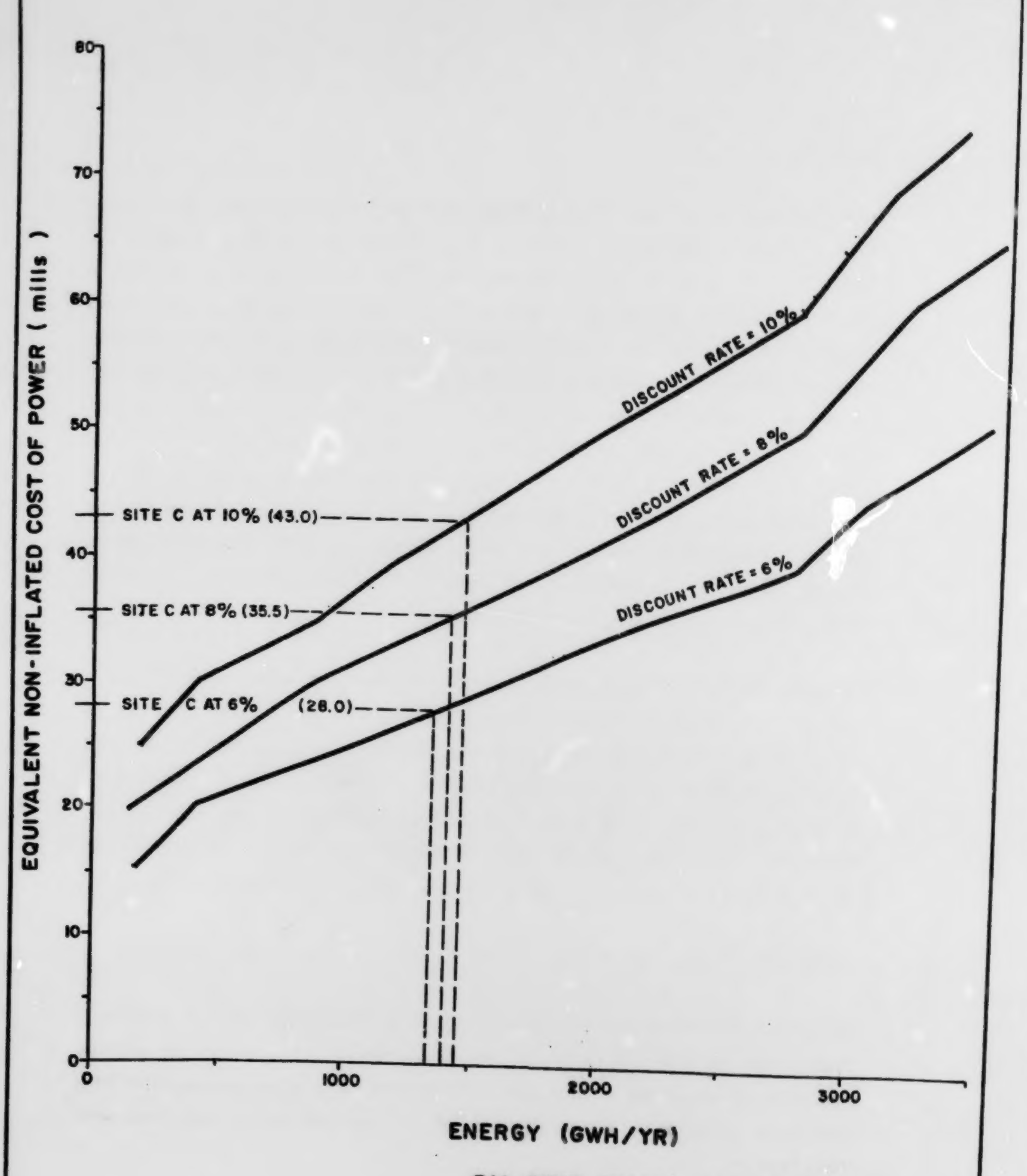
### Summary

It is important to correctly interpret the findings of the above discussion in the light of the survey nature of the study. It cannot necessarily be concluded that the collection of small hydro power sites identified here as economically feasible, should affect the scheduling of Peace Site C or other major generation projects. Firstly, the evaluation is built up from preliminary cost estimates that were prepared according to accepted standards, but without the benefit of on-site information. Some of the sites included here may prove to be not technically developable. However, it is also likely that a number of feasible sites were overlooked, particularly low-head sites, sites requiring storage and other conditions impossible to identify on a map survey, and sites found in the **Resource Assessment** but omitted here because of insufficient information. Secondly, economic feasibility is only one consideration in assessing the overall desirability of small hydro power development.

Financial feasibility is assessed in Section 3. However, environmental, social and land use constraints must also be considered. Lastly, the logistics of acquiring the necessary approvals, and constructing a large number of sites in a relatively short period may be constraining. Nevertheless, it is correct to conclude that the small hydro power resource offers an economically attractive, essentially unexploited energy source which is worthy of consideration as a supplement to the energy reserve of British Columbia.

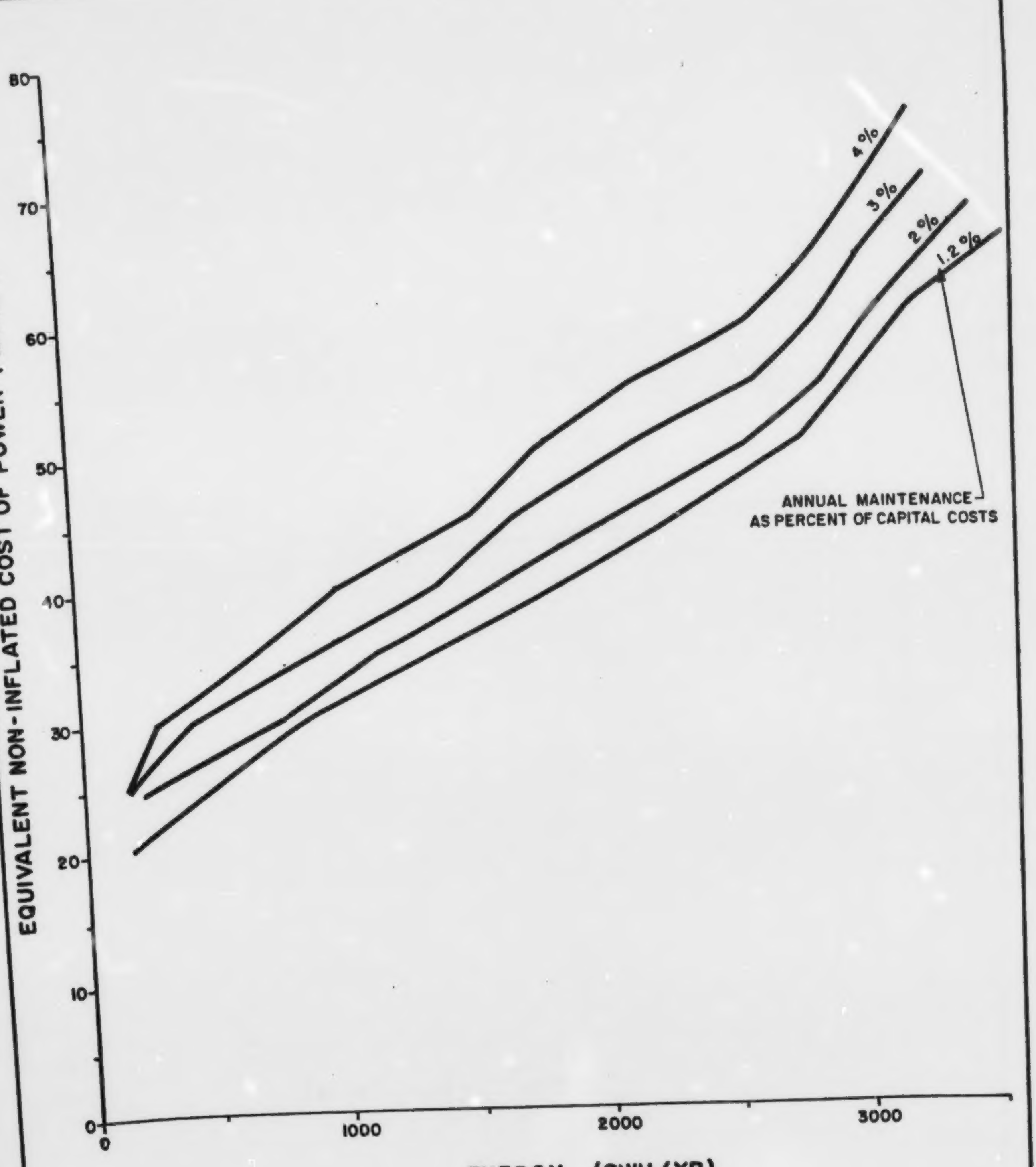
## 2.3 SENSITIVITY ANALYSIS

The most important factors influencing the conclusions of the economic analysis are the discount rate, the cost of operation and maintenance and the possibility of exporting surplus power during the early years of operation of a large scale hydro power plant, Figures 2-6, 2-7 and 2-8 respectively deal with these factors.



ON-GRID SMALL HYDRO POWER
INCREMENTAL ENERGY CAPABILITY
vs. INCREMENTAL COST OF POWER
(Sensitivity to discount rate)

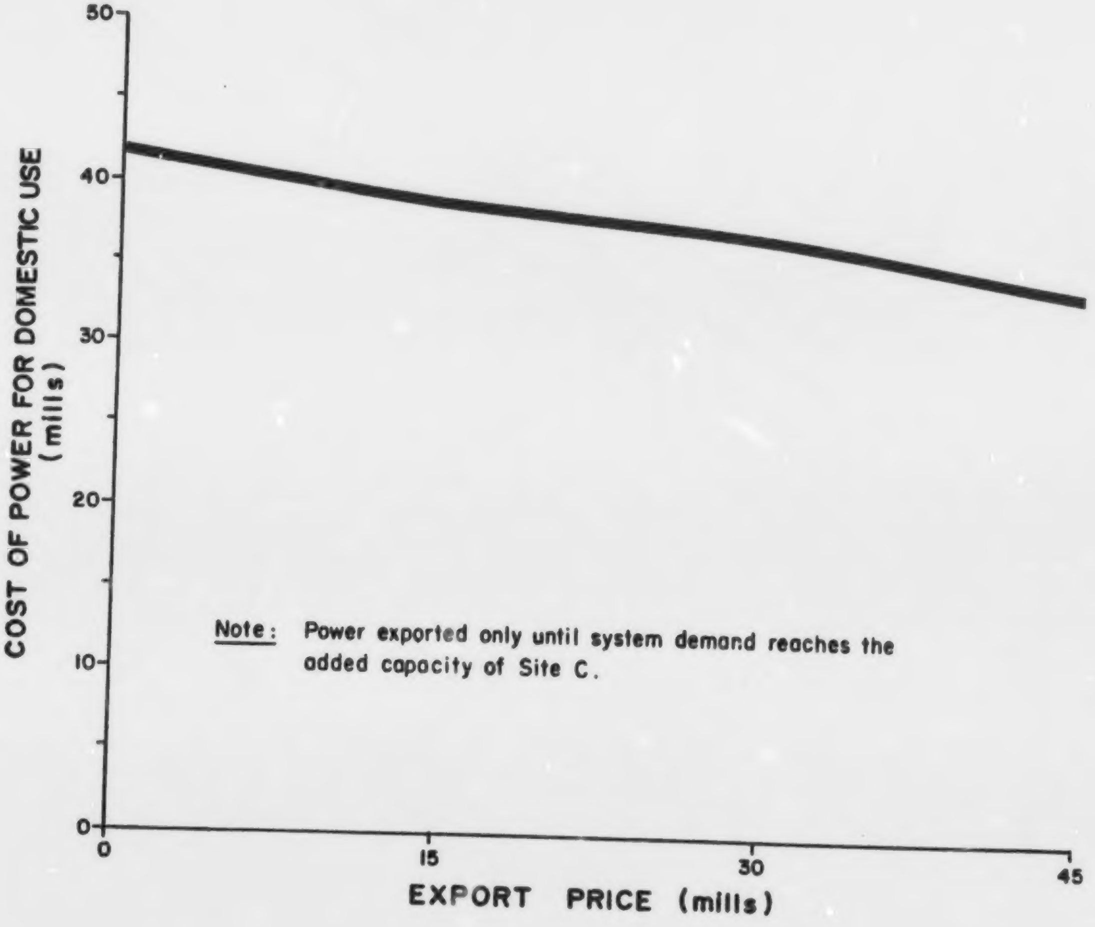
FIGURE 2.6



ON-GRID SMALL HYDRO POWER
INCREMENTAL ENERGY CAPABILITY
vs. INCREMENTAL COST OF POWER
(Sensitivity to maintenance cost)

FIGURE 2.7

6.978 DCS



COST OF SITE C POWER vs. EXPORT PRICE

FIGURE 2.8

5276 DCS

Figure 2-6 illustrates that although the cost of power is sensitive to the discount rate, the relative costs between large and small hydro power is not strongly affected. However, there is a slight tendency for reduced relative cost of small hydro power at increasing discount rates because of its relatively shorter lead time and development period.

Figure 2-7 illustrates that the cost of small hydro power is sensitive to the level of operation and maintenance costs. At a cost level of 35 mills the quantity of feasible power drops from about 1300 GW.h/year to about 700 GW.h/year as the level of costs rises from 1.2 percent up to 4 percent of capital costs.

Figure 2-8 illustrates how the economic cost of power from Peace Site C is affected by the export price of surplus power. The cost drops from about 42 mills if no export market is available down to 34 mills if export of surplus power is possible at 45 mills. This cost range corresponds to an amount of on-grid feasible small hydro power ranging from about 2100 GW.h/year for no export down to about 1200 GW.h/year for an export price of 45 mills.

## 2.4 OFF-GRID APPLICATIONS

Presently, there are a number of communities, tourist facilities, camps (logging and mining), park facilities, military establishments, and other settlements that are isolated from the provincial transmission grid. Electricity (if it is available) is generally provided to these settlements by local diesel generating plants operated either privately or by BC Hydro. The off-grid small hydro power potential refers to the technically feasible sites identified in the **Resource Assessment** that could supplement diesel generation in those areas served by BC Hydro.

Off-grid small hydro power development would generally supply some portion of the base load for the system, with the diesel unit meeting the load swings; electricity requirements during insufficient stream flow conditions; and emergencies. It is in this manner that BC Hydro currently operates the mixed (diesel and hydro) system at Bella Coola. It would generally not be the case that small hydro power would totally replace existing diesel units (i.e. offer capital cost savings). Rather, the existing diesel capacity would still be required, but it would operate less frequently. Under these conditions, the quantifiable economic benefit of off-grid small hydro power development is the value of the diesel fuel displaced.

For off-grid applications, the development of a small hydro power site(s) must be tailored to the electricity demands of the settlement served. For on-grid application, where the plant size is unconstrained by system demand, the optimal plant capacity is typically near the average flow of the stream. This may not be the case for off-grid applications, since the system load might dictate a plant of smaller capacity. Hence the data required to assess the economic feasibility of off-grid applications are not available given the survey level of this study. The off-grid potential of the small hydro power resource located near the diesel generating areas operated by BC Hydro is considered below. The analysis focussed on these areas because the pertinent information regarding the operating characteristics of the system was readily available. The analysis should, however, be considered indicative, rather than conclusive, since more detailed data are required to make a final judgment regarding the economic feasibility of small hydro power serving these communities.

BC Hydro presently operates 13 remote diesel generating stations serving communities currently isolated from the provincial grid. The largest non-integrated community is Fort Nelson, which uses natural gas to power its generators. The remaining 12 communities are considerably smaller and rely on diesel fuel for power generation. The smallest in terms of fewest customers is Telegraph Creek, with a total of 69 customers and a total electricity demand in 1981/82 of only 1.014 GW.h. The cost of diesel generation in terms of mills per kilowatt hour of electricity produced ranged from a high of 158 at Telegraph Creek to a low of 90 at Bella Coola (Table 2.2 - 2 sheets).

In the **Resource Assessment**, small hydro power potential was identified near eight of the 13 communities. Hence, there are remote communities that have identified small hydro power potential that could be developed at an

Sheet 1 of 2

## TABLE 2.2

## SMALL HYDRO POWER POTENTIAL NEAR B C HYDRO DIESEL GRID AREAS

| | | | Potential Small Hydro Power Sites | | |
|---|---|---|---|---|---|
| Location | Energy Demand (1982 GW.h) | Energy Cost(1) (Mills) | Stream Name | Energy Output (GW.h/Year | Economic Cost(2) (Mills) |
| Anahim Lake | 2.26 | 103 | None | - | - |
| Atlin | 2.38 | 162 | Fourth of July Creek | 3.1 | 222 |
| | | | Hitchcock Creek | 2.0 | 332 |
| | | | Indian Creek | 0.9 | 423 |
| | | | Pine Creek Ditch | 5.1 | 101 |
| | | | | 11.1 | |
| Bamfield | 3.17 | 107 | Handy Creek | 14.6 | 35 |
| | | | Macktush Creek | 5.4 | 72 |
| | | | | 20.0 | |
| Bella Bella | 7.57 | 122 | None | - | - |
| Bella Coola | 11.11 | 90 | Cacoohtin Creek | 14.7 | 28 |
| | | | Clayton Falls Creek | 16.5 | 37 |
| | | | Thorsen Creek | 19.9 | 50 |
| | | | Snootli Creek | 13.8 | 37 |
| | | | | 64.9 | |
| Dease Lake | 2.80 | 252(3) | None | - | - |
| Eddontenajon | 0.96 | - | None | - | - |
| Masset | 18.36 | 107 | Lignite Creek | 11.7 | 85 |
| Sandspit | 17.56 | 111 | Sachs Creek | 4.4 | 69 |
| | | | Tlell River | 2.7 | 225 |
| | | | Haans Creek | 3.7 | 206 |
| | | | Unnamed Creek (at 53 08; 131 53) | 1.6 | 219 |
| | | | | 12.4 | |

(1) Based on fuel, operation and maintenance costs only

(2) Computed as described in Appendix 2

(3) Includes administration costs not directly related to Dease Lake

Sheet 2 of 2

## TABLE 2.2

## SMALL HYDRO POWER POTENTIAL NEAR B C HYDRO DIESEL GRID AREAS

| Location | Energy Demand (1982 GW.h) | Energy Cost(1) (Mills) | Potential Small Hydro Power Sites | | |
|---|---|---|---|---|---|
| | | | Stream Name | Energy Output (GW.h/Year | Economic Cost(2) (Mills) |
| Stewart | 12.83 | 127 | American Creek | 16.0 | 71 |
| | | | Bear River | 5.3 | 38 |
| | | | Blackstock Creek | 7.6 | 138 |
| | | | Cascade River | 8.7 | 50 |
| | | | Glacier Creek | 6.1 | 73 |
| | | | Mamat Creek | 11.8 | 158 |
| | | | | 55.0 | |
| Telegraph Creek | 1.01 | 158 | Dodjatin Creek | 2.7 | 113 |
| | | | Eight Mile Creek | 0.7 | 237 |
| | | | Mess Creek | 40.6 | 71 |
| | | | Telegraph Creek | 2.4 | 102 |
| | | | Nine Mile Creek | 1.2 | 192 |
| | | | | 47.6 | |
| Tatla Lake | 0.95 | 147 | Unnamed Creek (at 51 55; 124 44) | 0.7 | 281 |
| | | | Unnamed Creek (at 51 26; 124 45) | 5.1 | 106 |
| | | | Lincoln Creek | 0.9 | 248 |
| | | | | 6.7 | |
| | | | | 229.4 | |

average cost that is less than the cost of diesel fuel. These communities include Atlin, Bella Coola, Sandspit, Stewart, Tatla Lake, Telegraph Creek, and Bamfield. A total of 35 sites were identified that could potentially supply electricity at a lower average cost than diesel.

For most communities, the identified small hydro power potential is greatly in excess of the load requirements. For example, six potential small hydro power sites were identified around the settlement of Stewart. Four could be developed at an average cost of less than 127 mill/kW.h (the average cost of diesel) and provide an energy capability of nearly 36.1 GW.h/year. However, current load requirements are only in the order of 13 GW.h/yr. With further study, the most suitable site(s) could be identified and the plant capacity sized to the system requirements. With the exception of Sandspit, where only one attractive site has been identified, the remaining five communities are similar to the example of Stewart noted above.

Further work is required to assess the economic feasibility of off-grid applications for small hydro power development. This will require more detailed site assessment as well as defining the role of small hydro power in an integrated diesel/hydro system. In contrast to on-grid applications, where the incremental capacity does not appear to be required until the early 1990s, off-grid applications offer an immediate cost savings. The development of off-grid small hydro power could also provide additional operational experience from which the more intensive on-grid development could benefit.

# 3. FINANCIAL ASSESSMENT OF THE SMALL HYDRO POWER RESOURCE

In Section 2 the economic value of the small hydro power resource was established, leading to an assessment of the amount of potential capacity for which development may be encouraged. The criterion for economic feasibility of a site was taken to be whether it could provide lower cost energy than the large scale hydro power sites which are likely to be next in line to be developed as the provincial power load exceeds present committed capacity. On this basis it was concluded that at least 50 and up to 80 of the lowest cost, undeveloped small hydro power sites could be economically feasible. This represents an installed peak generating capacity of from 300 MW to 432 MW, or energy outputs of from 1370 GW.h/year to 1970 GW.h/year.

Optimal scheduling of the development of this power would ensure that there was adequate power available to meet provincial demand when load exceeds present capacity at some time in the future. Present forecasts indicate this will be in about 1990 when about 555 GW.h/year of energy will be needed, increasing to 1111 GW.h/year in 1991, and 1944 GW.h/year in 1992. If the economically feasible portion of the small hydro power resource were developed in a timely manner it could in effect meet provincial load growth for over two years.

The economic analysis however does not present a complete description of project feasibility, and the process by which these sites might be implemented must be considered primarily in terms of the actual factors that motivate or inhibit possible developers of small hydro power sites.

Small hydro power plants could be developed by either B C Hydro or a private developer. The motivation for B C Hydro to develop the small hydro power resource would be to provide firm energy at a lower cost than it could by alternative methods such as large scale hydro or thermal plants. The normal motivation for private developers would be the opportunity for profit. However the development of plants by private developers implies a policy whereby B C Hydro would buy power and distribute it, or whereby B C Hydro would wheel power to other purchasers.

In Section 3.1 the general factors influencing financial feasibility are described; then in Section 3.2 a financial analysis of a typical small hydro power development is presented, primarily from the perspective of a private developer. The objective is to analyze all cost, revenue and risk factors that a developer will experience, and thus to determine the sale price of power that must be achievable to make small hydro power projects attractive investments. This methodology is then applied to the inventory of actual sites as covered in Section 3.3. A long-run supply curve of small hydro power is derived that relates the quantity of power likely to be developed to the price level of power. This will appear similar to the economic supply curves in Section 2. However, it includes non-economic factors experienced by developers such as water rent, income tax, school tax and an increased discount rate due to higher sensitivity to risk.

## 3.1 FACTORS INFLUENCING FINANCIAL FEASIBILITY

The factors which influence the financial feasibility of a project include all those that could affect the revenues, costs, timing or uncertainties of the project; also all the economic factors discussed in the preceding chapter such as:

- capital costs of the plant;
- capital cost of transmission to the grid or location of use;
- operation and maintenance costs;
- management costs;
- transmission and downtime losses.

The developer of a small hydro power plant under existing legislation will experience the following additional costs which are real from his point of view but which do not directly represent economic costs:

**Water Rent**

Prior to the starting of operation of a small hydro power plant the holder of a water licence must pay a fee of $0.50 per kW of licensed generating capacity. When the plant goes into operation the fee is $2.50 per thousand kW.h of power generated plus $5.00 per kW of installed capacity. These rates are adjusted periodically and for the the purpose of this analysis have been assumed to escalate at the same rate as the price of electric power.

### School Tax

Almost all real property and improvements in the province of British Columbia are liable for school tax. Small hydro power plants are assessable and taxable at rates established annually by regulation as provided by the Assessment Act and Schools Act. Assessments are based upon the current replacement cost for utility property, less depreciation allowances where applicable. Small hydro power plants are taxable on 35 percent of the actual value of assessable property. The 1982 weighted average mill rate was about 55 mills. School tax costs are assumed to escalate at the general inflation rate.

It is significant to note that the only properties specifically exempted from school tax are hydro power generating facilities on the Columbia River and Peace River. Since school taxes are one of the major operating costs of a small hydro power plant, the exemption of some large scale hydro power plants results in a distortion of the relative financial feasibility of these projects. This aspect is further discussed in Section 4 covering policy opportunities.

### Utility Tax

B C Hydro pays annual grants to municipalities (and to the provincial government for rural areas), in lieu of the general municipal property taxes paid by private owners of real property. The tax is computed as 1 percent of electric revenues from annual sales within the boundaries of each municipality. This tax would not be directly charged to the owner/operator of a small hydro power facility, but would be paid by the agency distributing the power. Therefore, this tax has not been included in the financial analysis.

## Project Financing

Hydro power developments are capital intensive, requiring relatively large capital expenditures followed by relatively small operating expenses after startup. This expenditure profile implies a declining net unit cost over the lifetime of a project. Furthermore, in the long run, the value of power can reasonably be expected to increase at a rate exceeding the general inflation rate. These factors create difficulties in the financing of hydro power projects by conventional level payment, declining balance loans. Nearly all hydro power projects (even if financially profitable on a net present value basis) show negative cash flows during early years followed by many years of expected large positive cash flows. Private developers of small hydro power projects are likely to be deterred by the initial years of negative cash flow even given the certainty of future profits.

Large utilities can overcome this problem through the use of revolving debt. For example, under instructions from the provincial government, BC Hydro is moving toward achieving a 130 percent coverage of gross debt interest where unamortized debt declines over the life of a project. This results in high initial power prices which decline over the life of a project.

A developer of a small hydro power project, however will probably not be able to obtain such a pricing schedule because his power must be priced at competititve rates immediately. An alternative would be to finance with a graduated payment loan linked to project net income so that positive cash flows are always obtained. This would result in an increasing principal balance in early years, which is repaid by increased payments in later years.

Such loan schemes are not likely to be available at present from the commercial financial markets without some form of government guarantee. As Section 3 deals with the financial feasibility of small hydro power projects under current conditions, the analysis will be based on conventional financing only. Innovative financing schemes as well as other alternatives for overcoming the problem of early negative cash flows will be dealt with more fully in Section 4.

## Income Tax

Income tax is the most difficult factor to interpret in determining the general financial feasibility of the small hydro power resource. This is because different types of project developers may be taxed in different ways, ranging from utilities which pay no income tax, to individuals and corporations which are subject to full tax liability. The federal government has introduced an accelerated depreciation (capital cost allowance) scheme for tax purposes which permits private investors to depreciate the investment in three years (25%, 50%, 25% respectively) (Reference 11). The resulting tax losses in the early years can result in tax savings on other income which could be a substantial encouragement to private investors with taxable income from other sources. Note that accelerated depreciation will be of little value to investors with no other income to shelter. This accelerated capital cost allowance option is due to expire in 1985. If not renewed it will probably be replaced by the conventional capital cost allowance rate of 6 percent for these types of facilities. Financial analysis will be carried out for both types of capital cost allowance, but recommendations will be based on the conventional rate because most small hydro power development is likely to occur after 1985.

These factors make it impossible to produce generalized statements about the financial feasibility of small hydro power for all investors. The approach here will be to analyze feasibility for the following typical types of investors:

- investors who pay no income tax (for example, utilities);
- investors who only have income from the project itself (investors who cannot take advantage of the tax shelter afforded by the accelerated tax write off);
- investors who have other income which can be sheltered by tax losses from a project.

In the latter two cases a 50 percent marginal income tax rate was assumed.

### Required Rate of Return

The economic evaluation presented in Section 3 used an 8 percent discount rate for evaluating future benefits which is equivalent to providing an 8 percent internal rate of return on capital. This discount rate is applicable to projects from the viewpoint of the entire province of British Columbia which is presumably so large that the risks and uncertainties of any given project are insignificant. However, a developer contemplating a single project will be more sensitive to risks and would require a higher rate of return as compensation. Such risks may also make it more difficult to obtain financing at a favourable rate. For the purpose of this analysis a risk premium of one per cent over the social discount rate has been assumed as a base case which results in a real rate of return of 9 percent or a nominal rate of return of 15 percent, assuming a rate of inflation of 7 percent. This is somewhat optimistic for the first small hydro power plants to be developed because they will be unfamiliar to investors. Therefore the first few plants may have to yield a higher return, perhaps 19 percent nominal, but the required yield should decline as the projects become familiar as investments. The first few investors will also likely be involved in the more attractive sites and thus a higher return should be readily available.

Factors which affect the uncertainty perceived by a developer will affect his required rate of return, and thus can affect the financial feasibility of a project. Therefore factors such as uncertainty of stream flows, capital costs and operating costs will increase the rate of return required by the developer. Other risk-related factors are more controllable by the appropriate government policies including uncertainty about the approval of a water licence, the ability to sell power and the sale price of power. The options and benefits of controlling risk will be discussed further in Section 4.

## 3.2 FINANCIAL FEASIBILITY ANALYSIS OF A TYPICAL PROJECT

Two computer models were developed to aid in the financial analysis of small hydro power sites. One model produces a detailed financial analysis of a site by forecasting all cash flows and determining the present value and internal rate of return given the sale price of power. The other model carried out a reverse analysis whereby the price of power necessary to achieve a given rate of return is calculated given the costs and other assumptions about a site.

The first model was used to produce Tables 3.1, 3.2 and 3.3 which illustrate the financial feasibility analysis of a typical small hydro power project. The analysis is for Perketts Creek which was ranked as the 15th best site out of all 521 on-grid sites for which cost analysis was done in the **Resource Assessment**. Table 3.1 outlines the input parameters which include the following:

Peak power output (installed capacity) of 4500 kW
Total plant capital cost of $5,436,000
Firmness factor of 55 percent
Discount rate of 15 percent
Power inflation rate of 7 percent
General inflation rate of 6 percent
Conventional debt at 80 percent of costs at a 12 percent interest rate
Income tax rate of 50 percent
Capital cost allowance of 6 percent per year
Power sales at 35 mills

Table 3.2 shows the cash flows during the two year construction period. Equity and management fees are assumed to go into the project in proportion to hard costs. Hard costs are assumed to be incurred at an increasing rate as the year of completion is approached.

Table 3.3 shows the overall cash flows during the 50 year life of the project. Income from power sales is assumed to start in the year after completion of construction at which time it is $781,900, and to escalate thereafter. The net income of $510,900 in the first year is determined by deducting operation and maintenance costs ($73,300 in the first year), water rent ($80,100), and school tax ($117,600). All these costs escalate during the life of the project. Loan payments of $639,000 start in the first year of operation and continue during the assumed amortization period of 30 years.

# TABLE 3.1 - SAMPLE INPUTS TO SMALL HYDRO FINANCIAL ANALYSIS MODEL

**(Based on Perketts Creek)**

```
PEAK POWER OUTPUT (KW)                4,500
ENERGY OUTPUT (GWH/YR)                 19.5
HARD COST OF PLANT ($1000)          4,536.0
HARD COST OF TRNSMISSION ($1000)      900.0
TOTAL HARD CAPITAL COST ($1000)     5,436.0
FIRMNESS FACTOR (%)                    55.0

START YEAR                             1982
HORIZON (YRS OF OPERATION)             50.0
DOWNTIME & XMISSION LOSSES (%)         10.0
DESIRED RATE OF RETURN (%)             15.0
POWER INFLATION RATE (%)                7.0
GENERAL INFLATION RATE (%)              6.0
1ST YR. O & M (TRANSMISSION)            1.2 PERCENT OF CAPITAL COSTS
1ST YR. O & M (GENERATION)              1.2 PERCENT OF CAPITAL COSTS
AVERAGE ASSET LIFE (YEARS)            1,000
EQUITY (% OF DEVEL. COST)              20.0
LOAN AMOUNT (SEE AT RIGHT)          5,147.3
EQUITY AMOUNT (SEE AT RIGHT)        1,286.8
DEBT INTEREST RATE (%)                 12.0
AMORTIZATION PERIOD (YEARS)            30.0
LOAN PAYMENT ($1000)                  639.0
INCOME TAX RATE (%)                    50.0
ASSESSMENT RATIO (%)                   35.0
UTILITY TAX RATE (% OF POWER)           0.0
MEAN XMISSION LOSS TO USER (%)          9.0
MEAN SYSTEM MILL RATE                  31.5
SCHOOL TAX RATE (MILLS)                55.0
WATER RENT:
  ON ENERGY PRODUCED                   2.50  DOLLARS PER 1000 KW/YEAR
  ON INSTALLED CAPACITY
     DURING CONSTRUCTION               0.50  DOLLARS PER KWH OF CAPACITY/YEAR
     DURING OPERATION                  5.00  DOLLARS PER KWH OF CAPACITY/YEAR
CONSTRUCTION INTEREST RATE (%)         14.0
DEVELOPMENT PERIOD (YEARS)                2
MANAG. FEE (% OF CAPITAL COST)          8.0

CAPITAL COST ALLOWANCE (%)              6.0 (ENTER -1 FOR ACCELERATED RATE)
DEBT COVERAGE RATIO                   -1.00 (ENTER -1 FOR NO DEBT PAYMENT CEILING)

UNINTERRUPTABLE POWER:
  SALE PRICE (MILLS)                    0.0
  PERCENT OF TOTAL POWER                0.0
INTERRUPTIBLE POWER:
  SALE PRICE (MILLS)                   35.0
  PERCENT OF TOTAL POWER              100.0
```

## TABLE 3.2 - ANALYSIS OF DEVELOPMENT PERIOD AND OVERALL RATE OF RETURN FROM SMALL HYDRO FINANCIAL ANALYSIS MODEL

(Based on Perketts Creek)

DEVELOPMENT PERIOD

| YEAR | CONSTRUCTION COST | MANAGEMENT COST | EQUITY DURING CONSTRUCTION | INTEREST COST | CUMULATIVE DEBT | CUMULATIVE COST | LONG TERM LOAN DRAW | TOTAL EQUITY |
|---|---|---|---|---|---|---|---|---|
| 1982 | 1,812.0 | 145.0 | 391.4 | 109.6 | 1,675.2 | 2,066.5 | 0.0 | 391.4 |
| 1983 | 3,624.0 | 289.9 | 782.8 | 453.7 | 5,260.0 | 6,434.2 | 5,147.3 | 895.4 |
| 1984 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1985 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1986 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1987 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1988 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | 5,436.0 | 434.9 | 1,174.2 | 563.3 | 5,260.0 | 6,434.2 | 5,147.3 | 1,286.8 |

PRESENT VALUES AND RATES OF RETURN

| | |
|---|---|
| PRESENT VALUE BEFORE INCOME TAX | 766.6 |
| PRESENT VALUE AFTER INCOME TAX | 423.4 |
| IRR AFTER INCOME TAX | 17.7 |

TABLE 3.3 - CASH FLOWS DURING OPERATIONAL PERIOD FROM SMALL HYDRO

| YEAR | POWER VALUE |  |  | OPERATION AND MAINTENANCE | WATER RENT | SCHOOL TAX | UTILITY TAX | NET INCOME | TOTAL LOAN PAYMENT | PRINCIPAL BALANCE (YR END) | INTEREST PAYMENT | EQUITY INFLOW | BEFORE TAX CASH FLOW | UNRECOV. BALANCE (YR END) | CAPITAL COST ALLOWANCE | TAXABLE INCOME | TAX PAYABLE | AFTER TAX CASH FLOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | INTERRUP. | UNINTERRUP. | TOTAL |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1982 | 0.0 | 0.0 | 0.0 | 0.0 | 2.3 | 0.0 | 0.0 | -2.3 | 0.0 | 0.0 | 0.0 | 391.4 | -393.6 | 0.0 | 0.0 | -2.3 | -1.1 | -392.5 |
| 1983 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.0 | 0.0 | -2.4 | 0.0 | 5,147.3 | 0.0 | 895.4 | -897.8 | 4,434.2 | 0.0 | -2.4 | -1.2 | -896.6 |
| 1984 | 781.9 | 0.0 | 781.9 | 73.3 | 80.1 | 117.6 | 0.0 | 510.9 | 639.0 | 5,126.0 | 617.7 | 0.0 | -128.1 | 6,040.1 | 386.1 | -492.8 | -246.4 | 118.3 |
| 1985 | 836.6 | 0.0 | 836.6 | 77.7 | 84.9 | 124.5 | 0.0 | 549.5 | 639.0 | 5,102.1 | 615.1 | 0.0 | -89.5 | 5,695.2 | 362.9 | -428.5 | -214.2 | 124.7 |
| 1986 | 895.2 | 0.0 | 895.2 | 82.4 | 90.0 | 131.8 | 0.0 | 591.0 | 639.0 | 5,075.4 | 612.3 | 0.0 | -48.0 | 5,344.1 | 341.1 | -362.4 | -181.2 | 133.2 |
| 1987 | 957.9 | 0.0 | 957.9 | 87.3 | 95.4 | 139.6 | 0.0 | 635.6 | 639.0 | 5,045.4 | 609.0 | 0.0 | -3.4 | 5,023.5 | 320.6 | -294.1 | -147.1 | 143.6 |
| 1988 | 1,024.9 | 0.0 | 1,024.9 | 92.5 | 101.1 | 147.8 | 0.0 | 683.4 | 639.0 | 5,011.8 | 605.4 | 0.0 | 44.4 | 4,727.1 | 301.4 | -223.4 | -111.7 | 156.1 |
| 1989 | 1,096.7 | 0.0 | 1,096.7 | 98.1 | 107.2 | 156.6 | 0.0 | 734.8 | 639.0 | 4,974.2 | 601.4 | 0.0 | 95.8 | 4,438.7 | 283.3 | -149.9 | -74.9 | 170.8 |
| 1990 | 1,173.4 | 0.0 | 1,173.4 | 104.0 | 113.6 | 165.8 | 0.0 | 790.1 | 639.0 | 4,932.2 | 596.9 | 0.0 | 151.1 | 4,177.4 | 266.3 | -73.2 | -36.6 | 187.6 |
| 1991 | 1,255.6 | 0.0 | 1,255.6 | 110.2 | 120.4 | 175.6 | 0.0 | 849.4 | 639.0 | 4,885.0 | 591.9 | 0.0 | 210.4 | 3,922.1 | 250.3 | 7.2 | 3.6 | 206.8 |
| 1992 | 1,343.5 | 0.0 | 1,343.5 | 116.8 | 127.7 | 185.9 | 0.0 | 913.1 | 639.0 | 4,832.2 | 586.2 | 0.0 | 274.1 | 3,686.7 | 235.3 | 91.6 | 45.8 | 228.3 |
| 1993 | 1,437.5 | 0.0 | 1,437.5 | 123.8 | 135.3 | 196.9 | 0.0 | 981.5 | 639.0 | 4,773.0 | 579.9 | 0.0 | 342.5 | 3,465.3 | 221.2 | 180.4 | 90.2 | 252.3 |
| 1994 | 1,538.1 | 0.0 | 1,538.1 | 131.3 | 143.4 | 208.5 | 0.0 | 1,055.0 | 639.0 | 4,706.8 | 572.8 | 0.0 | 416.0 | 3,257.6 | 207.9 | 274.3 | 137.1 | 278.9 |
| 1995 | 1,645.8 | 0.0 | 1,645.8 | 139.1 | 152.0 | 220.7 | 0.0 | 1,133.9 | 639.0 | 4,632.6 | 564.8 | 0.0 | 494.9 | 3,067.2 | 195.5 | 373.6 | 186.8 | 308.1 |
| 1996 | 1,761.0 | 0.0 | 1,761.0 | 147.5 | 161.2 | 233.7 | 0.0 | 1,218.6 | 639.0 | 4,549.5 | 555.9 | 0.0 | 579.6 | 2,878.4 | 183.7 | 479.0 | 239.5 | 340.1 |
| 1997 | 1,884.3 | 0.0 | 1,884.3 | 156.3 | 170.8 | 247.5 | 0.0 | 1,309.6 | 639.0 | 4,456.4 | 545.9 | 0.0 | 670.6 | 2,705.7 | 172.7 | 591.0 | 295.5 | 375.1 |
| 1998 | 2,016.2 | 0.0 | 2,016.2 | 165.7 | 181.1 | 262.1 | 0.0 | 1,407.3 | 639.0 | 4,352.2 | 534.8 | 0.0 | 768.3 | 2,543.4 | 162.3 | 710.2 | 355.1 | 413.2 |
| 1999 | 2,157.3 | 0.0 | 2,157.3 | 175.7 | 191.9 | 277.6 | 0.0 | 1,512.2 | 639.0 | 4,235.5 | 522.3 | 0.0 | 873.2 | 2,390.8 | 152.6 | 837.3 | 418.6 | 454.5 |
| 2000 | 2,308.3 | 0.0 | 2,308.3 | 186.2 | 203.5 | 293.9 | 0.0 | 1,624.8 | 639.0 | 4,104.7 | 508.3 | 0.0 | 985.8 | 2,247.3 | 143.4 | 973.1 | 486.5 | 499.2 |
| 2001 | 2,469.9 | 0.0 | 2,469.9 | 197.4 | 215.7 | 311.2 | 0.0 | 1,745.6 | 639.0 | 3,958.3 | 492.6 | 0.0 | 1,106.6 | 2,112.5 | 134.8 | 1,118.2 | 559.1 | 547.5 |
| 2002 | 2,642.8 | 0.0 | 2,642.8 | 209.2 | 228.6 | 329.6 | 0.0 | 1,875.4 | 639.0 | 3,794.2 | 475.0 | 0.0 | 1,236.4 | 1,985.7 | 126.7 | 1,273.7 | 636.8 | 599.6 |
| 2003 | 2,827.8 | 0.0 | 2,827.8 | 221.8 | 242.3 | 349.0 | 0.0 | 2,014.7 | 639.0 | 3,610.5 | 455.3 | 0.0 | 1,375.7 | 1,866.6 | 119.1 | 1,440.3 | 720.1 | 655.6 |
| 2004 | 3,025.7 | 0.0 | 3,025.7 | 235.1 | 256.9 | 369.5 | 0.0 | 2,164.3 | 639.0 | 3,404.8 | 433.3 | 0.0 | 1,525.3 | 1,754.6 | 112.0 | 1,619.0 | 809.5 | 715.8 |
| 2005 | 3,237.6 | 0.0 | 3,237.6 | 249.2 | 272.3 | 391.3 | 0.0 | 2,324.8 | 639.0 | 3,174.4 | 408.6 | 0.0 | 1,685.8 | 1,649.3 | 105.3 | 1,810.9 | 905.5 | 780.3 |
| 2006 | 3,464.2 | 0.0 | 3,464.2 | 264.1 | 288.6 | 414.4 | 0.0 | 2,497.1 | 639.0 | 2,916.3 | 380.9 | 0.0 | 1,858.1 | 1,550.4 | 99.0 | 2,017.2 | 1,008.6 | 849.5 |
| 2007 | 3,706.7 | 0.0 | 3,706.7 | 279.9 | 305.9 | 439.3 | 0.0 | 2,682.0 | 639.0 | 2,627.2 | 350.0 | 0.0 | 2,043.0 | 1,457.3 | 93.0 | 2,239.0 | 1,119.5 | 923.5 |
| 2008 | 3,966.1 | 0.0 | 3,966.1 | 296.7 | 324.3 | 464.6 | 0.0 | 2,880.4 | 639.0 | 2,303.5 | 315.3 | 0.0 | 2,241.4 | 1,369.9 | 87.4 | 2,477.7 | 1,238.9 | 1,002.6 |
| 2009 | 4,243.8 | 0.0 | 4,243.8 | 314.6 | 343.7 | 492.0 | 0.0 | 3,093.4 | 639.0 | 1,940.9 | 276.4 | 0.0 | 2,454.4 | 1,287.7 | 82.2 | 2,734.8 | 1,367.4 | 1,087.0 |
| 2010 | 4,540.8 | 0.0 | 4,540.8 | 333.4 | 364.4 | 521.0 | 0.0 | 3,322.0 | 639.0 | 1,534.8 | 232.9 | 0.0 | 2,683.0 | 1,210.4 | 77.3 | 3,011.9 | 1,505.9 | 1,177.1 |
| 2011 | 4,858.7 | 0.0 | 4,858.7 | 353.5 | 386.3 | 551.7 | 0.0 | 3,567.3 | 639.0 | 1,080.0 | 184.2 | 0.0 | 2,928.3 | 1,137.8 | 72.6 | 3,310.5 | 1,655.3 | 1,273.1 |
| 2012 | 5,198.8 | 0.0 | 5,198.8 | 374.7 | 409.4 | 584.2 | 0.0 | 3,830.5 | 639.0 | 570.5 | 129.6 | 0.0 | 3,191.5 | 1,069.5 | 68.3 | 3,632.7 | 1,816.3 | 1,375.2 |
| 2013 | 5,562.7 | 0.0 | 5,562.7 | 397.1 | 434.0 | 618.6 | 0.0 | 4,113.0 | 639.0 | 0.0 | 68.5 | 0.0 | 3,474.0 | 1,005.4 | 64.2 | 3,980.4 | 1,990.2 | 1,483.8 |
| 2014 | 5,952.1 | 0.0 | 5,952.1 | 421.0 | 460.0 | 655.0 | 0.0 | 4,416.1 | 0.0 | 0.0 | 0.0 | 0.0 | 4,416.1 | 945.1 | 60.3 | 4,355.8 | 2,177.9 | 2,238.2 |
| 2015 | 6,368.8 | 0.0 | 6,368.8 | 446.2 | 487.6 | 693.6 | 0.0 | 4,741.3 | 0.0 | 0.0 | 0.0 | 0.0 | 4,741.3 | 888.3 | 56.7 | 4,684.6 | 2,342.3 | 2,399.0 |
| 2016 | 6,814.6 | 0.0 | 6,814.6 | 473.0 | 516.9 | 734.5 | 0.0 | 5,090.2 | 0.0 | 0.0 | 0.0 | 0.0 | 5,090.2 | 835.0 | 53.3 | 5,036.9 | 2,518.5 | 2,571.7 |
| 2017 | 7,291.6 | 0.0 | 7,291.6 | 501.4 | 547.9 | 777.8 | 0.0 | 5,464.6 | 0.0 | 0.0 | 0.0 | 0.0 | 5,464.6 | 784.9 | 50.1 | 5,414.5 | 2,707.2 | 2,757.3 |
| 2018 | 7,802.0 | 0.0 | 7,802.0 | 531.5 | 580.8 | 823.6 | 0.0 | 5,866.2 | 0.0 | 0.0 | 0.0 | 0.0 | 5,866.2 | 737.8 | 47.1 | 5,819.1 | 2,909.6 | 2,956.7 |
| 2019 | 8,348.1 | 0.0 | 8,348.1 | 563.3 | 615.6 | 872.1 | 0.0 | 6,297.1 | 0.0 | 0.0 | 0.0 | 0.0 | 6,297.1 | 693.6 | 44.3 | 6,252.8 | 3,126.4 | 3,170.7 |
| 2020 | 8,932.5 | 0.0 | 8,932.5 | 597.2 | 652.5 | 923.4 | 0.0 | 6,759.4 | 0.0 | 0.0 | 0.0 | 0.0 | 6,759.4 | 652.0 | 41.6 | 6,717.8 | 3,358.9 | 3,400.5 |
| 2021 | 9,557.8 | 0.0 | 9,557.8 | 633.0 | 691.7 | 977.8 | 0.0 | 7,255.3 | 0.0 | 0.0 | 0.0 | 0.0 | 7,255.3 | 612.9 | 39.1 | 7,216.2 | 3,608.1 | 3,647.2 |
| 2022 | 10,226.8 | 0.0 | 10,226.8 | 671.0 | 733.2 | 1,035.4 | 0.0 | 7,787.3 | 0.0 | 0.0 | 0.0 | 0.0 | 7,787.3 | 576.1 | 36.8 | 7,750.5 | 3,875.2 | 3,912.1 |
| 2023 | 10,942.7 | 0.0 | 10,942.7 | 711.2 | 777.2 | 1,096.4 | 0.0 | 8,357.9 | 0.0 | 0.0 | 0.0 | 0.0 | 8,357.9 | 541.5 | 34.6 | 8,323.3 | 4,161.7 | 4,196.2 |
| 2024 | 11,708.7 | 0.0 | 11,708.7 | 753.9 | 823.8 | 1,161.0 | 0.0 | 8,970.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8,970.0 | 509.0 | 32.5 | 8,937.5 | 4,468.8 | 4,501.2 |
| 2025 | 12,528.3 | 0.0 | 12,528.3 | 799.1 | 873.2 | 1,229.4 | 0.0 | 9,624.6 | 0.0 | 0.0 | 0.0 | 0.0 | 9,624.6 | 478.5 | 30.5 | 9,594.1 | 4,797.0 | 4,827.6 |
| 2026 | 13,405.3 | 0.0 | 13,405.3 | 847.1 | 925.6 | 1,301.8 | 0.0 | 10,330.8 | 0.0 | 0.0 | 0.0 | 0.0 | 10,330.8 | 449.8 | 28.7 | 10,302.1 | 5,151.1 | 5,179.8 |
| 2027 | 14,343.7 | 0.0 | 14,343.7 | 897.9 | 981.2 | 1,378.6 | 0.0 | 11,086.2 | 0.0 | 0.0 | 0.0 | 0.0 | 11,086.2 | 422.8 | 27.0 | 11,059.2 | 5,529.6 | 5,556.6 |
| 2028 | 15,347.7 | 0.0 | 15,347.7 | 951.8 | 1,040.0 | 1,459.6 | 0.0 | 11,896.3 | 0.0 | 0.0 | 0.0 | 0.0 | 11,896.3 | 397.4 | 25.4 | 11,870.9 | 5,935.5 | 5,960.8 |
| 2029 | 16,422.0 | 0.0 | 16,422.0 | 1,008.9 | 1,102.4 | 1,545.6 | 0.0 | 12,765.2 | 0.0 | 0.0 | 0.0 | 0.0 | 12,765.2 | 373.6 | 23.8 | 12,741.3 | 6,370.7 | 6,394.5 |
| 2030 | 17,571.6 | 0.0 | 17,571.6 | 1,069.4 | 1,168.6 | 1,636.6 | 0.0 | 13,697.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13,697.0 | 351.2 | 22.4 | 13,674.6 | 6,837.3 | 6,859.7 |
| 2031 | 18,801.6 | 0.0 | 18,801.6 | 1,133.6 | 1,238.7 | 1,733.0 | 0.0 | 14,696.4 | 0.0 | 0.0 | 0.0 | 0.0 | 14,696.4 | 330.1 | 21.1 | 14,675.3 | 7,337.6 | 7,358.8 |
| 2032 | 20,117.7 | 0.0 | 20,117.7 | 1,201.6 | 1,313.0 | 1,835.3 | 0.0 | 15,768.1 | 0.0 | 0.0 | 0.0 | 0.0 | 15,768.1 | 310.3 | 19.8 | 15,748.3 | 7,874.1 | 7,894.0 |
| 2033 | 21,526.0 | 0.0 | 21,526.0 | 1,273.7 | 1,391.8 | 1,943.1 | 0.0 | 16,917.4 | 0.0 | 0.0 | 0.0 | 0.0 | 16,917.4 | 291.7 | 18.6 | 16,898.8 | 8,449.4 | 8,468.0 |
| 2034 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2035 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2036 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2037 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2038 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | 7 189.6 | 0.0 | 7 189.6 | 645.3 | 665.2 | 960.4 | 0.0 | 4 950.6 | 3 172.6 |  | 2 039.1 | 1 087.4 | 760.6 |  | 1 399.0 | 680.6 | 345.2 | 423.6 |

The before-tax cashflow is calculated by deducting the loan payment from the net income. It can be seen that negative before-tax flows are experienced for the first four years of operation because of the use of conventional debt financing. Taxable income is calculated by deducting loan interest and the capital cost allowance from net income. Capital cost allowance is based on the normal six percent declining balance method. This results in availability of a tax shelter for other income resulting in negative tax being payable during the early years. This means tax savings on other income. In the example it can be seen that the tax sheltering effect is maximum in the first year of operation at which time it has a value of $492,800. Thus the after-tax cash flow is positive during the early years of operation because of the assumed tax savings on other income. However these tax shelter benefits would only be available to a developer who has as considerable other taxable income as the available tax shelter in a given year.

It is possible to determine the relative significance of these factors by comparing them on a net present value basis over the life of the project (Table 3-4). It can be seen that school taxes are the largest expense (13.3 percent of gross income). Water rent and operation and maintenance are smaller and of about equal magnitude (9.3 percent and 8.4 percent respectively).

If the accelerated capital cost allowance method had been used then the CCA deduction would have been $1,609,000 in the first year, $3,216,000 in the second year, $1,609,000 in the third year and zero thereafter. This would have resulted in large tax losses being available to shelter other income.

## TABLE 3 - 4
## NET PRESENT VALUES OF COSTS AND REVENUE ITEMS OVER THE LIFE OF A TYPICAL SMALL HYDRO POWER PROJECT
(Discount Rate of 15%)

| | Item | Net Present Value ($1,000) | Percent of Gross Income | Calculation |
|---|---|---|---|---|
| (1) | Gross Income from Power Sales | 7,190 | 100 | - |
| (2) | Operation and Maintenance Costs | 605 | 8.4 | - |
| (3) | Water Rent | 665 | 9.3 | - |
| (4) | School Tax | 960 | 13.3 | - |
| (5) | Net Income | 4,959 | 69.0 | (1)-(2)-(3)-(4) |
| (6) | Total Loan Payment | 3,173 | 44.1 | - |
| (7) | Interest Payment | 2,878 | 40.0 | - |
| (8) | Equity | 1,017 | 14.1 | - |
| (9) | Before Tax Cash Flow | 769 | 10.7 | (5)-(6)-(8) |
| (10) | Capital Cost Allowance | 1,390 | 19.3 | - |
| (11) | Taxable Income | 690 | 9.6 | (5)-(7)-(10) |
| (12) | Tax Payable | 345 | 4.8 | 0.5 x (11) |
| (13) | After Tax Cash Flow | 423 | 5.9 | (9) - (12) |

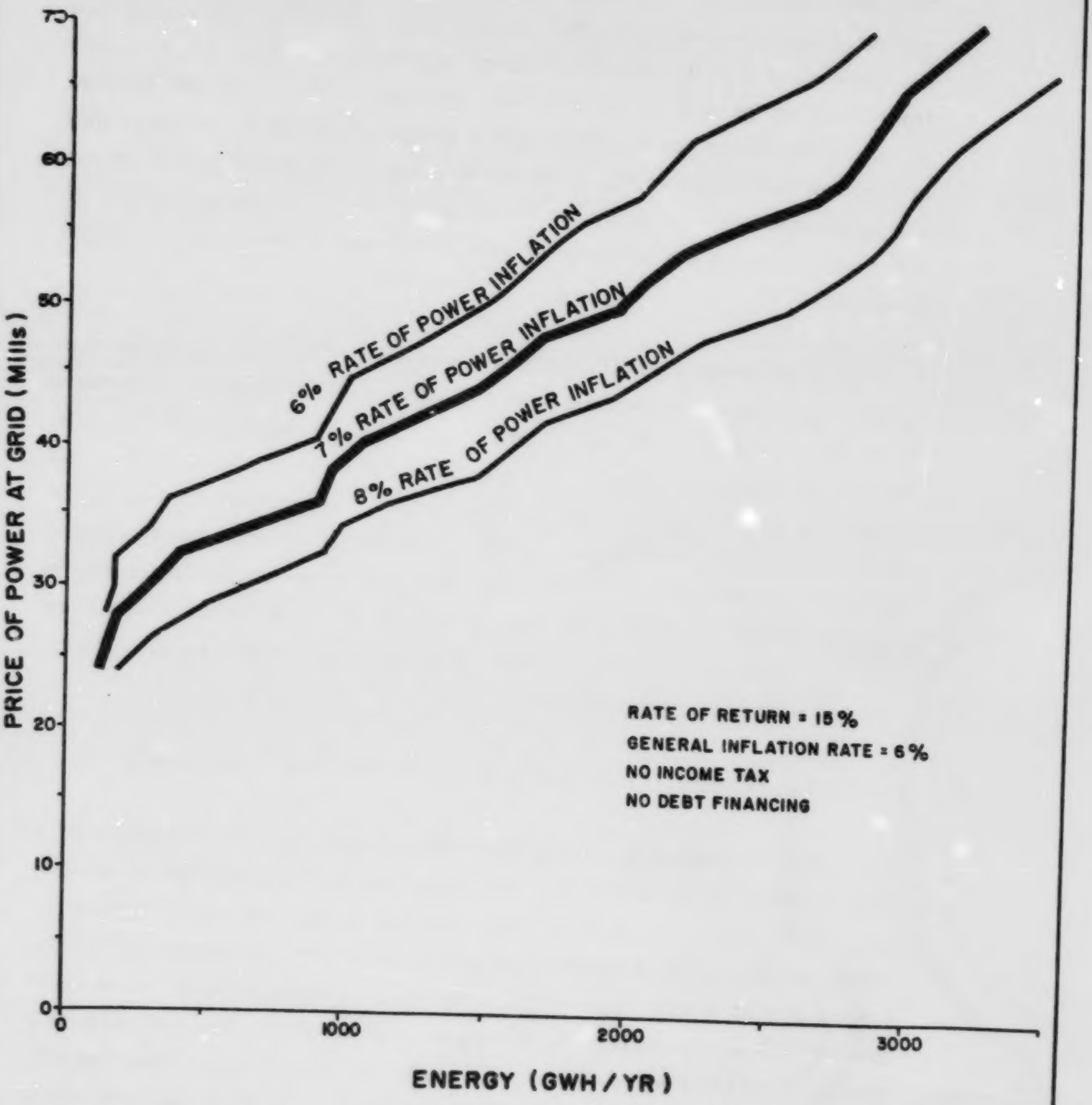
The same basic methodology applies to any small hydro power site, whether on-grid or off-grid. It is assumed that on-grid plants can sell all the energy that they produce so that the amount of energy supplied can be determined directly from the plant generating capacity and firmness factor. Also, the price of power will be dictated by B C Hydro unless wheeling is allowed. This price may or may not be related to the incremental value of the power to B C Hydro. During the course of the study, no formal definitive policy was available from B C Hydro covering the purchase of power from private developers in British Columbia.

The price of power for off-grid sites is given by the opportunity cost of generating the power by the next best alternative method. In most cases this is by diesel generation which can indicate power values in the order of 100 mills. Another consideration which is more important for off-grid sites is that the demand for power may not match the availability. The appropriate load factor must be determined by detailed analysis of stream flow versus power demand during the day and throughout the year. The load factor will never exceed the firmness factor. In general, the high opportunity value of power makes more likely the financial feasibility of small hydro power for off-grid use even though load factors may be relatively low.

## 3.3 FINANCIAL FEASIBILITY OF THE SMALL HYDRO POWER RESOURCE

Given that the preceding type of analysis can determine the feasibility of a given small hydro project, it remains to be seen how the quantity of feasible small hydro power depends on the price of power and other factors, or conversely, the price of power necessary to encourage the development of the desired amount of small hydro power. As the price level of power increases in real terms it will be feasible to develop more power sites. This analysis is only relevant for sites that could be connected to the integrated grid because off-grid projects are too site-specific to deal with at a single assumed price. Therefore, the following analysis will only deal with on-grid sites.

The introduction to this Section indicated an objective of determining the quantity of power which is feasible to develop at various price levels. In this



ON-GRID SMALL HYDRO POWER
QUANTITY OF FINANCIALLY FEASIBLE POWER
vs. PRICE OF POWER

FIGURE 3.1

1976 DCS

study we have used the Peace Site C Project as the reference for determining economically feasible power (about 1370 GW.h/year of energy). In fact it is difficult to give a definitive answer because financial feasibility is highly sensitive to factors such as the growth rate of power prices, the target rate of return, the income tax rate of the developer, the availability of other income to use tax shelter benefits and many other factors.

Table 3.5 illustrates this problem. It was calculated using a computer program which determines the necessary power price to provide a given rate of return. The program determines the necessary price for each of the 521 potential on-grid sites and tabulates the amount of energy available at each increment of price level. It can be seen that assuming no tax costs or benefits and no debt financing, the quantity of feasible power at a price of 35 mills rises from 282 GW.h/year to 930 GW.h/year as the inflation rate of power rises from 6 percent to 8 percent. Similarly, for 7 percent power price inflation the quantity of feasible power rises from 129 GW.h/year to 590 GW.h/year as the price of power rises from 25 mills to 35 mills. Similar sensitivity can be seen when income tax and/or debt financing are assumed. In the after-tax cases the significant benefit of the accelerated write-off is clear. The most useful case on which to base a determination of the necessary price for a given amount of feasible power is the no tax/no debt case (Figure 3.1). This is because cases which assume debt are based on conventional debt financing which, as described above, results in years of negative cashflows which would probably not be acceptable to a developer. Any assumption of tax without debt financing is unduly pessimistic because the tax deductibility of interest is an important benefit in debt financing which in effect reduces the interest rate by up to 50 percent. It can be seen that the assumption of taxes, accelerated depreciation and debt financing results in the possible feasibility of large amounts of power at reasonable prices. In fact more power could be feasible than would be economically desirable. As stated above, conclusions should not be based on debt scenarios which are unrealistic. However, it is likely that if a modified graduated payment financing scheme can be found, it might have benefits which are intermediate between the tax/no debt and tax/conventional debt scenarios shown in Table 3.5. This is discussed further in Section 4.

## TABLE 3.5
## FINANCIAL FEASIBILITY OF ON-GRID POWER
(Quantity of Energy in GW.h per year)

| Assumptions | | | | Price of Power at Grid (Mills) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Income Tax Payable | CCA | Debt | Power Inflation | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| No | N/A | No | 6% | 0 | 0 | 170 | 282 | 590 | 930 | 1,337 |
| No | N/A | No | 7% | 0 | 129 | 170 | 590 | 930 | 1,451 | 1,763 |
| No | N/A | No | 8% | 0 | 170 | 547 | 930 | 1,506 | 1,960 | 2,381 |
| No | N/A | Yes | 6% | 0 | 0 | 170 | 412 | 870 | 1,165 | 1,610 |
| No | N/A | Yes | 7% | 0 | 170 | 332 | 870 | 1,227 | 1,610 | 2,085 |
| No | N/A | Yes | 8% | 0 | 282 | 870 | 1,249 | 1,659 | 2,156 | 2,721 |
| Yes | 6% | No | 6% | 0 | 0 | 0 | 0 | 0 | 170 | 170 |
| Yes | 6% | No | 7% | 0 | 0 | 0 | 0 | 170 | 170 | 412 |
| Yes | 6% | No | 8% | 0 | 0 | 0 | 170 | 282 | 432 | 870 |
| Yes | Accel. | No | 6% | 0 | 0 | 0 | 170 | 170 | 412 | 870 |
| Yes | Accel. | No | 7% | 0 | 0 | 129 | 170 | 432 | 870 | 1,115 |
| Yes | Accel. | No | 8% | 0 | 0 | 170 | 446 | 892 | 1,226 | 1,594 |
| Yes | 6% | Yes | 6% | 0 | 0 | 170 | 412 | 872 | 1,267 | 1,594 |
| Yes | 6% | Yes | 7% | 0 | 170 | 332 | 870 | 1,337 | 1,659 | 2,108 |
| Yes | 6% | Yes | 8% | 129 | 282 | 870 | 1,337 | 1,738 | 2,227 | 2,810 |
| Yes | Accel. | Yes | 6% | 170 | 892 | 1,506 | 2,108 | 2,799 | 3,042 | 3,543 |
| Yes | Accel. | Yes | 7% | 547 | 1,295 | 2,000 | 2,754 | 3,064 | 3,585 | 4,124 |
| Yes | Accel. | Yes | 8% | 930 | 1,770 | 2,688 | 3,072 | 3,756 | 4,221 | 4,546 |

See following page for assumptions.

## ASSUMPTIONS FOR TABLE 3.5

(1) Where applicable, debt financing is at 12% and is assumed to be at 80% of costs amortized over a period of 30 years. Note that this type of financing may not be possible because it results in negative before-tax cashflows for up to 10 years as shown in Table 3.3. This is discussed further in the next chapter.

(2) Accelerated capital cost allowance is calculated using the 25%, 50%, 25% formula. (Reference 11)

(3) General inflation of 6%.

(4) Target rate of return of 15%.

(5) Time horizon of 50 years.

(6) Operation and maintenance costs of 1.2% of capital costs.

(7) Water rent of $2.50 per 1000 kW.h per year plus $5.00 per kW of installed capacity.

(8) Income tax rate of 50%.

(9) Losses can be written off against other income.

(10) Two year construction period.

(11) 14% construction financing rate.

(12) Management fee of 8% of capital costs during construction.

Therefore, on a before-tax/no debt basis for a power inflation rate of 7% (1% above the general inflation rate), a power price of 40 to 45 mills would be required for as much power to be financially feasible as was found to be economically feasible (1370 GW.h/year). On an after-tax/no debt basis the price would have to be over 50 mills while on an after-tax/debt basis more than enough power would be feasible at a price of 25 mills (assuming the availability of accelerated capital cost allowance). However, a price of 35 to 40 mills would be required if only the standard 6 percent capital cost allowance were available. If the typical developer did not have other taxable income to use the tax shelter benefits then the pricing of feasible power would be similar to the no tax/debt case. This is because no tax would be payable until the project was fully depreciated which would take many years. In this case a price of about 40 mills would be necessary to make feasible the desired amount of power.

# 4. POLICY OPPORTUNITIES TO MATCH THE ECONOMIC AND FINANCIAL FEASIBILITY OF THE SMALL HYDRO POWER RESOURCE

Government policy towards a resource should be to encourage development of the economically feasible quantity, timed such as to maximize the net present value of its development consistent with provincial demand. Based on the preceding analysis we have estimated that at least 1370 GW.h/year of energy (the best 54 small hydro power sites), should be seriously considered for connection to the integrated grid(1). The optimal timing might be such that enough power is available to help meet provincial load growth by about the year 1990 based on current demand forecasts.

The financial analysis indicates that under some conditions at least this much power could be financially feasible at present. However, there are impediments which make it unlikely that this much power would be undertaken by private developers in the foreseeable future. Assuming that B C Hydro will not develop this power itself, then the appropriate role for public policy would be to ensure the development of the power by the private sector.

## 4.1 OBJECTIVES OF POLICY

An effective policy toward small hydro power development should respond to the following problems and objectives:

### Ensure Proper Level of Development

The most important objective is to ensure that the small hydro power resource is neither underdeveloped nor overdeveloped. It should ensure an orderly staged development of the better sites as the power is required. The economic section of this study provides a framework for determining the optimal staging and ultimate level of development of the small hydro power resource although more detailed site-specific studies will be required to confirm the result.

---

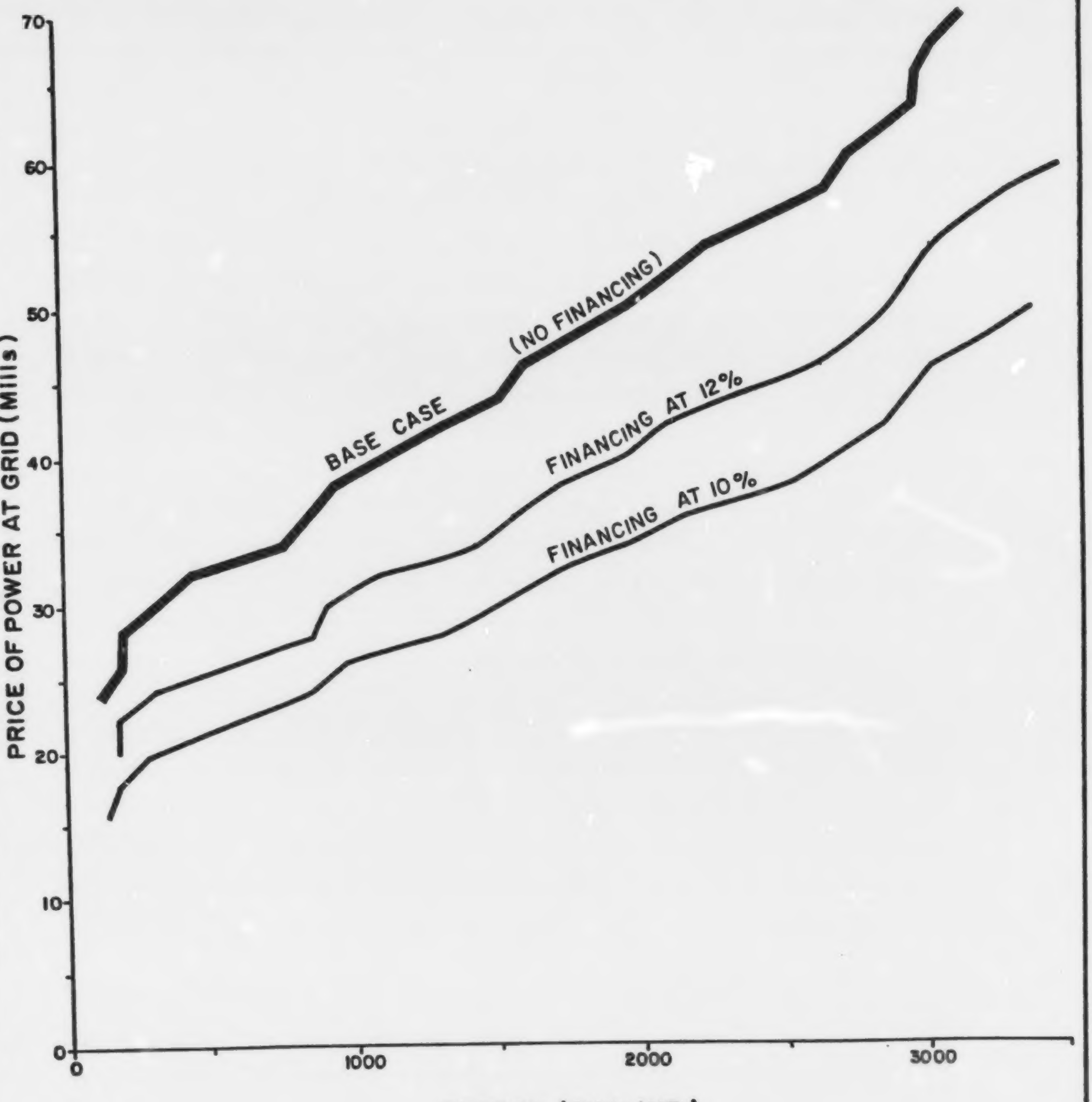
(1) Note that because of the survey nature of this study that has not allowed site-specific analysis, some of these sites may not be developable due to environmental or other constraints. However, it is likely that some good low head or other sites have been missed which would tend to counterbalance these losses.

The optimal level of development should be based on the cost of electric power that could be deferred by the development of the small hydro power resource. All small hydro power sites that can provide power at a lower cost than the next best alternative should be developed, subject to technical, environmental and other constraints. It was estimated that approximately 1370 GW.h per year (54 sites) of energy could be provided for a lower cost than 35 mills which is our estimated economic cost of power from Peace Site C. Peace Site C is the next scheduled large hydro power site to be developed. Development of the small hydro power resource can therefore be timed so that substantial power is available around 1990 when provincial load is forecast to exceed supply.

## Project Financing by the Private Developer

We have discussed the difficulty of debt financing of small hydro power developments. The problem is that hydro power projects are capital intensive so that conventional level-payment loans result in many years of negative cashflows. Appropriate financing can have a dramatic effect on project feasibility (see Figure 4.1). However, the commercial financial market is unlikely to entertain with great enthusiasm, loans on projects that might experience up to 10 years of negative pre-tax cash flows. This is true even for developers who are eligible for tax benefits large enough to offset early operating losses. It is considered that to be viable a project should be able to stand alone without the benefit of tax write-offs.

One indicated remedy would be to establish a re-financing scheme which would permit the developer to obtain positive cash flows in the early years in exchange for a reduction in future cash flows. This could be done at normal commercial interest rates and thus would not represent a subsidy. However, such loans are not likely to be available from the conventional financial markets at present. They might be available in the future after there are enough successful projects in operation to demonstrate their feasibility. However this may take years. One alternative is that such loans might be available if they were guaranteed by the government. However, a potential problem with this solution is that the government may be forced to take over many of these projects after the tax benefits to the developer are exhausted.



IMPACT OF FINANCING ON
QUANTITY OF FEASIBLE ON-GRID POWER

FIGURE 4.1

It would appear preferable to develop a policy that does not tamper with the normal financing mechanism for projects. The policy should more directly address the features of small hydro power projects which are causing negative cash flows.

## Power Price Structure

The price at which the operator of a small hydro power plant can sell power is obviously a critical factor affecting feasibility. The two main aspects to power pricing are the price level and the assurance of the future price level. The price level should be related to the value of power to the purchaser. B C Hydro has estimated its marginal cost of expanding system capacity to be 35.9 mills at a discount rate of 8 percent (Reference 5). The economic cost of Peace Site C power was estimated to be about 35 mills. These factors indicate that when the demand for power in British Columbia exceeds the present system capacity, the cost of additional power capacity will be at least 35 mills. Thus, in the following analysis, a 35 mill purchase price of power was assumed. In fact a higher purchase price may be warranted when other financial factors related to large hydro power development are considered.

Much more study could be devoted to developing a more accurate value based on avoided cost. Factors that should be considered include the value of non-firm power; the additional value of avoiding some transmission losses by direct supply to the lower voltage segments of the grid; and the possible use of a dual level price scheme whereby the firm portion of the power from a site is paid for at a higher price.

Another option could be to permit the wheeling of power through the B C Hydro grid. This would allow a small hydro power operator to contract to sell power to a user anywhere on the grid at rates and on terms agreeable to both parties and pay a fee to BC Hydro for the use of the grid. For example, it might be possible for developers to supply power to West Kootenay Power and Light from anywhere in British Columbia.

In general, it is considered that the pricing of power should be required to reflect its value and the amount of small hydro power that is feasible at that price should be developed. This is the approach which has been taken in the United States where generation-related payments to private power facilities are required to be based on the marginal energy cost of the purchasing utility. If under these conditions not as much power is financially feasible as would be desirable based on economic considerations, then there must be other distortions in the market that should be corrected by appropriate policies.

## Optimal Development Timing

The development of small hydro power sites should be phased to match provincial demand. If development timing decisions were left entirely to the private sector, there would be no assurance of achieving this because of long development lead times, uncertainty of approval and imperfections in the pricing mechanism as a guide to project timing.

One option would be to control development timing with a provincial agency that licenses sites for development as required based on forecasts of demand. This would require a reasonably accurate inventory of the resource so that appropriate planning could be done. Site licences would tend to limit speculation.

Another method of controlling the timing of development would be to issue energy purchase contracts only when needed to meet forecast demand, but to depend on the private sector to find the sites and propose them for development.

## Uncertainty of Approval

Another problem at present is the possibility of bureaucratic blockages which have to be overcome before a project can be developed. Three types of provincial legislation are involved - water rights, environmental considerations and electrical distribution. There is no streamlined mechanism for moving a project through these approvals. Coupled with the high cost of initial feasibility studies, this could represent a serious impediment to the development of otherwise feasible sites.

Two policies are proposed here for dealing with these impediments. First, the provincial government could undertake more detailed studies of the resource to help to reduce the front-end study costs of the developer. This would also provide the information necessary to confidently plan the staging of development of the sites. Second, approval procedures should be streamlined. Assuming a policy of controlling the timing of development by licensing, a policy of reasonably assured approval of a site in a standard period of time could be provided when a site is licensed.

### Environmental Considerations

Small hydro power development is likely to be less environmentally damaging than large scale hydro power development. However, there are probably financially feasible sites that should not be developed for environmental reasons. The Ontario government has undertaken a blanket study of the environmental impact of small hydro power development which should help to reduce the costs of impact analysis for each site (Reference 10). This may also prove to be a valuable approach in British Columbia.

## 4.2 POLICIES

Given the above general policies and objectives, this section considers specific options to adjust the amount of feasible small hydro power to achieve the desired level of development.

### Overcoming Early Negative Cash Flows

There are three options. The price at which power is bought could be adjusted so that it is always high enough to cover operating costs and debt service. However as discussed above, tampering with the price mechanism is likely to disrupt the objective of achieving efficient development of the resource through the market.

A second option would be for the government to either provide financing directly or to provide loan guarantees for at least enough debt to cover the early deficits. However, it would probably be best to avoid this option if possible, as the prospect of incurring extra debt is unlikely to be appealing to the government. Also, it would be preferable to depend on the efficiency of the financial markets to provide appropriate rates and terms of financing as small hydro power projects become more accepted as a type of investment.

The final option would be to allow relief from provincial taxation at least during the critical early years of a project. This could involve either the water rent, the school tax or both. There are good reasons why relief from these taxes might be considered. It can be argued that the water rent should be reduced or eliminated because 'run of the river' small hydro power plants will not impede the normal flow of water in a stream and are not likely to cause environmental damage.

The school tax might be relaxed because the large hydro power projects which are being compared to small hydro power projects are specifically exempted from paying school tax. Furthermore, if these taxes were not relaxed many otherwise feasible small hydro power projects might not be developed, and thus would not have generated tax revenues anyway.

Table 4.1 (3 sheets) shows a printout of the impact of eliminating these taxes for a typical project. It can be seen that positive pre-tax cash flows are possible from the start of a project. Figure 4.2 illustrates the possible effect on the supply of power by elimination of the water rent.

Table 4.2 shows how reduction or elimination of these taxes could affect the number of years of negative cashflows. It can be seen that given an on-grid price of 35 mills, the elimination of both school tax and water rent could result in the feasibility of about 1245 GW.h/year of energy from small hydro power development. This assumes that a project would not be feasible if it is likely to produce more than four years of negative cashflows.

Table 4.1 <u>Effect on Cash Flows of Eliminating School Tax and Water Rent</u> (Part 1)

```
PEAK POWER OUTPUT (KW)                      4,500
ENERGY OUTPUT (GWH/YR)                       19.5
HARD COST OF PLANT ($1000)                4,536.0
HARD COST OF TRNSMISSION ($1000)            900.0
TOTAL HARD CAPITAL COST ($1000)           5,436.0
FIRMNESS FACTOR (%)                          55.0

START YEAR                                   1982
HORIZON (YRS OF OPERATION)                   50.0
DOWNTIME & XMISSION LOSSES (%)               10.0
DESIRED RATE OF RETURN (%)                   15.0
POWER INFLATION RATE (%)                      7.0
GENERAL INFLATION RATE (%)                    6.0
1ST YR. O & M (TRANSMISSION)                  1.2 PERCENT OF CAPITAL COSTS
1ST YR. O & M (GENERATION)                    1.2 PERCENT OF CAPITAL COSTS
AVERAGE ASSET LIFE (YEARS)                  1,000
EQUITY (% OF DEVEL. COST)                    20.0
LOAN AMOUNT (SEE AT RIGHT)                5,147.3
EQUITY AMOUNT (SEE AT RIGHT)              1,286.8
DEBT INTEREST RATE (%)                       12.0
AMORTIZATION PERIOD (YEARS)                  30.0
LOAN PAYMENT ($1000)                        639.0
INCOME TAX RATE (%)                          50.0
ASSESSMENT RATIO (%)                         35.0
UTILITY TAX RATE (% OF POWER)                 0.0
MEAN XMISSION LOSS TO USER (%)                9.0
MEAN SYSTEM MILL RATE                        31.5
SCHOOL TAX RATE (MILLS)                       0.0
WATER RENT:
   ON ENERGY PRODUCED                        0.00  DOLLARS PER 1000 KW/YEAR
   ON INSTALLED CAPACITY
      DURING CONSTRUCTION                    0.00  DOLLARS PER KWH OF CAPACITY/YEAR
      DURING OPERATION                       0.00  DOLLARS PER KWH OF CAPACITY/YEAR
CONSTRUCTION INTEREST RATE (%)               14.0
DEVELOPMENT PERIOD (YEARS)                      2
MANAG. FEE (% OF CAPITAL COST)                8.0

CAPITAL COST ALLOWANCE (%)                    6.0 (ENTER -1 FOR ACCELERATED RATE)
DEBT COVERAGE RATIO                         -1.00 (ENTER -1 FOR NO DEBT PAYMENT CEILING)

UNINTERRUPTABLE POWER:
   SALE PRICE (MILLS)                         0.0
   PERCENT OF TOTAL POWER                     0.0
INTERRUPTIBLE POWER:
   SALE PRICE (MILLS)                        35.0
   PERCENT OF TOTAL POWER                   100.0            OPERATIONAL PERIOD
```

Table 4.1 Effect on Cash Flows of Eliminating School Tax and Water Rent (Part 2)

DEVELOPMENT PERIOD

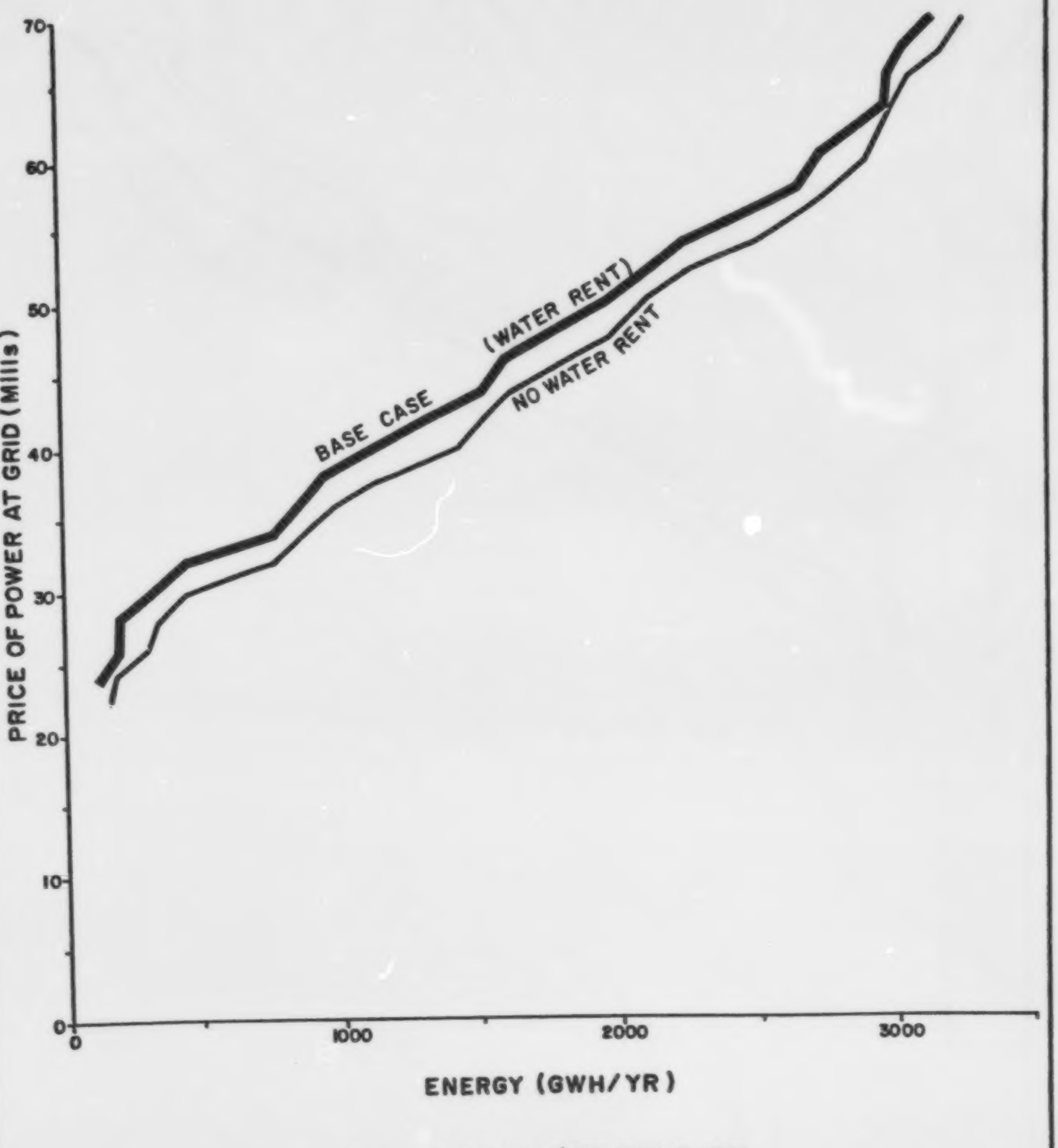
| YEAR | CONSTRUCTION COST | MANAGEMENT COST | EQUITY DURING CONSTRUCTION | INTEREST COST | CUMULATIVE DEBT | CUMULATIVE COST | LONG TERM LOAN DRAW | TOTAL EQUITY |
|---|---|---|---|---|---|---|---|---|
| 1982 | 1,812.0 | 145.0 | 391.4 | 109.6 | 1,675.2 | 2,066.5 | 0.0 | 391.4 |
| 1983 | 3,624.0 | 289.9 | 782.8 | 453.7 | 5,260.0 | 6,434.2 | 5,147.3 | 895.4 |
| 1984 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1985 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1986 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1987 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1988 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
|  | 5,436.0 | 434.9 | 1,174.2 | 563.3 | 5,260.0 | 6,434.2 | 5,147.3 | 1,286.8 |

PRESENT VALUES AND RATES OF RETURN

| | |
|---|---|
| PRESENT VALUE BEFORE INCOME TAX | 2,394.3 |
| PRESENT VALUE AFTER INCOME TAX | 1,236.2 |
| IRR AFTER INCOME TAX | 23.4 |

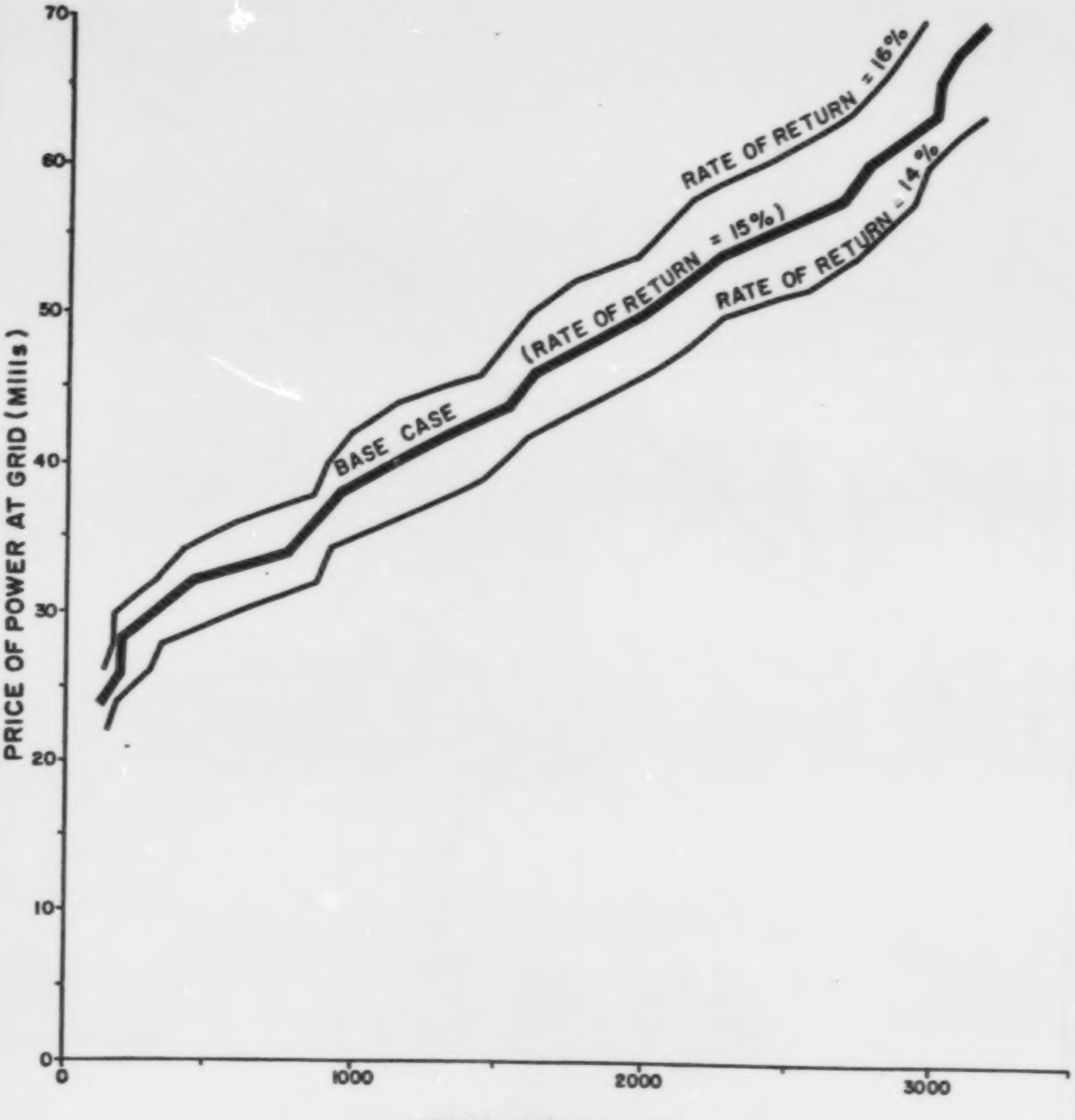
Table 4.1 Effect on Cash Flows of Eliminating School Tax and Water Rent (Part 3)

| | [illegible] VALUE | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | INTERRUP. | UNINTERRUP. | TOTAL | OPERATION AND MAINTENANCE | WATER RENT | SCHOOL TAX | UTILITY TAX | NET INCOME | TOTAL LOAN PAYMENT | PRINCIPAL BALANCE (YR END) | INTEREST PAYMENT | EQUITY INFLOW | BEFORE TAX CASH FLOW | DEPRECIAT. BALANCE (YR END) | CAPITAL COST ALLOWANCE | TAXABLE INCOME | TAX PAYMENT | AFTER TAX CASH FLOW |
| 1982 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 371.4 | -371.4 | 0.0 | 0.0 | 0.0 | 0.0 | -371.4 |
| 1983 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5,117.3 | 0.0 | 875.4 | -875.4 | 6,434.2 | 0.0 | 0.0 | 0.0 | -875.4 |
| 1984 | 781.9 | 0.0 | 781.9 | 73.3 | 0.0 | 0.0 | 0.0 | 708.6 | 639.0 | 5,126.0 | 617.7 | 0.0 | 69.6 | 6,048.1 | 384.1 | -295.1 | -147.6 | 217.2 |
| 1985 | 836.6 | 0.0 | 836.6 | 77.7 | 0.0 | 0.0 | 0.0 | 759.0 | 639.0 | 5,102.1 | 615.1 | 0.0 | 119.9 | 5,685.2 | 367.9 | -219.1 | -109.5 | 229.4 |
| 1986 | 895.2 | 0.0 | 895.2 | 82.4 | 0.0 | 0.0 | 0.0 | 812.9 | 639.0 | 5,075.4 | 617.3 | 0.0 | 173.8 | 5,344.1 | 341.1 | -140.5 | -70.3 | 244.1 |
| 1987 | 957.9 | 0.0 | 957.9 | 87.3 | 0.0 | 0.0 | 0.0 | 870.6 | 639.0 | 5,045.4 | 609.0 | 0.0 | 231.6 | 5,023.5 | 320.6 | -59.1 | -29.6 | 261.2 |
| 1988 | 1,024.9 | 0.0 | 1,024.9 | 92.5 | 0.0 | 0.0 | 0.0 | 932.4 | 639.0 | 5,011.8 | 605.4 | 0.0 | 293.4 | 4,777.1 | 301.4 | 25.5 | 12.8 | 280.6 |
| 1989 | 1,096.7 | 0.0 | 1,096.7 | 98.1 | 0.0 | 0.0 | 0.0 | 998.6 | 639.0 | 4,974.2 | 601.4 | 0.0 | 359.6 | 4,430.7 | 283.3 | 113.8 | 56.9 | 302.7 |
| 1990 | 1,173.4 | 0.0 | 1,173.4 | 104.0 | 0.0 | 0.0 | 0.0 | 1,069.5 | 639.0 | 4,932.2 | 596.9 | 0.0 | 430.5 | 4,177.4 | 266.3 | 206.7 | 103.1 | 327.3 |
| 1991 | 1,255.6 | 0.0 | 1,255.6 | 110.2 | 0.0 | 0.0 | 0.0 | 1,145.4 | 639.0 | 4,885.0 | 591.9 | 0.0 | 506.4 | 3,922.1 | 250.3 | 303.2 | 151.6 | 354.8 |
| 1992 | 1,343.5 | 0.0 | 1,343.5 | 116.8 | 0.0 | 0.0 | 0.0 | 1,226.6 | 639.0 | 4,832.2 | 586.2 | 0.0 | 587.6 | 3,686.7 | 235.3 | 405.1 | 202.5 | 385.1 |
| 1993 | 1,437.5 | 0.0 | 1,437.5 | 123.8 | 0.0 | 0.0 | 0.0 | 1,313.7 | 639.0 | 4,773.6 | 579.9 | 0.0 | 674.7 | 3,445.5 | 221.2 | 512.6 | 256.3 | 418.4 |
| 1994 | 1,538.1 | 0.0 | 1,538.1 | 131.3 | 0.0 | 0.0 | 0.0 | 1,406.9 | 639.0 | 4,706.8 | 572.8 | 0.0 | 767.9 | 3,237.6 | 207.9 | 626.7 | 313.1 | 454.8 |
| 1995 | 1,645.8 | 0.0 | 1,645.8 | 139.1 | 0.0 | 0.0 | 0.0 | 1,506.7 | 639.0 | 4,632.6 | 564.8 | 0.0 | 867.7 | 3,042.2 | 195.5 | 746.4 | 373.2 | 494.5 |
| 1996 | 1,761.0 | 0.0 | 1,761.0 | 147.5 | 0.0 | 0.0 | 0.0 | 1,613.5 | 639.0 | 4,549.5 | 555.9 | 0.0 | 974.5 | 2,878.4 | 183.7 | 873.9 | 436.9 | 537.6 |
| 1997 | 1,884.3 | 0.0 | 1,884.3 | 156.3 | 0.0 | 0.0 | 0.0 | 1,728.0 | 639.0 | 4,456.4 | 545.9 | 0.0 | 1,088.9 | 2,705.7 | 172.7 | 1,009.3 | 504.7 | 584.3 |
| 1998 | 2,016.2 | 0.0 | 2,016.2 | 165.7 | 0.0 | 0.0 | 0.0 | 1,850.5 | 639.0 | 4,352.2 | 534.8 | 0.0 | 1,211.5 | 2,543.4 | 162.3 | 1,153.4 | 576.7 | 634.8 |
| 1999 | 2,157.3 | 0.0 | 2,157.3 | 175.7 | 0.0 | 0.0 | 0.0 | 1,981.7 | 639.0 | 4,235.5 | 522.3 | 0.0 | 1,342.7 | 2,390.8 | 152.6 | 1,306.8 | 653.4 | 689.3 |
| 2000 | 2,308.3 | 0.0 | 2,308.3 | 186.2 | 0.0 | 0.0 | 0.0 | 2,122.1 | 639.0 | 4,104.7 | 508.3 | 0.0 | 1,483.1 | 2,247.3 | 143.4 | 1,470.4 | 735.2 | 747.9 |
| 2001 | 2,469.9 | 0.0 | 2,469.9 | 197.4 | 0.0 | 0.0 | 0.0 | 2,272.5 | 639.0 | 3,958.1 | 492.6 | 0.0 | 1,633.5 | 2,112.5 | 134.8 | 1,645.1 | 822.6 | 811.0 |
| 2002 | 2,642.8 | 0.0 | 2,642.8 | 209.2 | 0.0 | 0.0 | 0.0 | 2,433.6 | 639.0 | 3,794.2 | 475.0 | 0.0 | 1,794.6 | 1,985.7 | 126.7 | 1,831.9 | 915.9 | 878.7 |
| 2003 | 2,827.8 | 0.0 | 2,827.8 | 221.8 | 0.0 | 0.0 | 0.0 | 2,606.0 | 639.0 | 3,610.5 | 455.3 | 0.0 | 1,967.0 | 1,866.6 | 119.1 | 2,031.6 | 1,015.8 | 951.2 |
| 2004 | 3,025.7 | 0.0 | 3,025.7 | 235.1 | 0.0 | 0.0 | 0.0 | 2,790.7 | 639.0 | 3,404.8 | 433.3 | 0.0 | 2,151.7 | 1,754.6 | 112.0 | 2,245.4 | 1,122.7 | 1,029.0 |
| 2005 | 3,237.6 | 0.0 | 3,237.6 | 249.2 | 0.0 | 0.0 | 0.0 | 2,988.4 | 639.0 | 3,174.4 | 408.6 | 0.0 | 2,349.4 | 1,649.3 | 105.3 | 2,474.5 | 1,237.3 | 1,112.1 |
| 2006 | 3,464.2 | 0.0 | 3,464.2 | 264.1 | 0.0 | 0.0 | 0.0 | 3,200.1 | 639.0 | 2,916.3 | 380.9 | 0.0 | 2,561.1 | 1,550.4 | 99.0 | 2,720.2 | 1,360.1 | 1,201.0 |
| 2007 | 3,706.7 | 0.0 | 3,706.7 | 280.0 | 0.0 | 0.0 | 0.0 | 3,426.7 | 639.0 | 2,627.2 | 350.0 | 0.0 | 2,787.7 | 1,457.3 | 93.0 | 2,983.7 | 1,491.9 | 1,295.8 |
| 2008 | 3,966.1 | 0.0 | 3,966.1 | 296.8 | 0.0 | 0.0 | 0.0 | 3,669.4 | 639.0 | 2,303.5 | 315.3 | 0.0 | 3,030.4 | 1,369.9 | 87.4 | 3,266.7 | 1,633.3 | 1,397.0 |
| 2009 | 4,243.8 | 0.0 | 4,243.8 | 314.6 | 0.0 | 0.0 | 0.0 | 3,929.2 | 639.0 | 1,940.9 | 276.4 | 0.0 | 3,290.2 | 1,287.7 | 82.2 | 3,570.6 | 1,785.3 | 1,504.9 |
| 2010 | 4,540.8 | 0.0 | 4,540.8 | 333.4 | 0.0 | 0.0 | 0.0 | 4,207.4 | 639.0 | 1,534.8 | 232.9 | 0.0 | 3,568.4 | 1,210.4 | 77.3 | 3,897.2 | 1,948.6 | 1,619.8 |
| 2011 | 4,858.7 | 0.0 | 4,858.7 | 353.5 | 0.0 | 0.0 | 0.0 | 4,505.2 | 639.0 | 1,080.0 | 184.2 | 0.0 | 3,866.2 | 1,137.8 | 72.6 | 4,248.4 | 2,124.2 | 1,742.0 |
| 2012 | 5,198.8 | 0.0 | 5,198.8 | 374.7 | 0.0 | 0.0 | 0.0 | 4,824.1 | 639.0 | 570.5 | 129.6 | 0.0 | 4,185.1 | 1,069.5 | 68.3 | 4,626.3 | 2,313.1 | 1,872.0 |
| 2013 | 5,562.7 | 0.0 | 5,562.7 | 397.1 | 0.0 | 0.0 | 0.0 | 5,165.6 | 639.0 | 0.0 | 69.5 | 0.0 | 4,526.6 | 1,005.4 | 64.2 | 5,032.9 | 2,516.5 | 2,010.1 |
| 2014 | 5,952.1 | 0.0 | 5,952.1 | 421.0 | 0.0 | 0.0 | 0.0 | 5,531.1 | 0.0 | 0.0 | 0.0 | 0.0 | 5,531.1 | 945.1 | 60.3 | 5,470.8 | 2,735.4 | 2,795.7 |
| 2015 | 6,368.8 | 0.0 | 6,368.8 | 446.7 | 0.0 | 0.0 | 0.0 | 5,922.1 | 0.0 | 0.0 | 0.0 | 0.0 | 5,922.1 | 888.3 | 56.7 | 5,865.4 | 2,932.9 | 2,989.2 |
| 2016 | 6,814.6 | 0.0 | 6,814.6 | 473.0 | 0.0 | 0.0 | 0.0 | 6,341.6 | 0.0 | 0.0 | 0.0 | 0.0 | 6,341.6 | 835.0 | 53.3 | 6,288.3 | 3,144.1 | 3,197.4 |
| 2017 | 7,291.6 | 0.0 | 7,291.6 | 501.4 | 0.0 | 0.0 | 0.0 | 6,790.2 | 0.0 | 0.0 | 0.0 | 0.0 | 6,790.2 | 784.9 | 50.1 | 6,740.1 | 3,370.1 | 3,420.2 |
| 2018 | 7,802.0 | 0.0 | 7,802.0 | 531.5 | 0.0 | 0.0 | 0.0 | 7,270.5 | 0.0 | 0.0 | 0.0 | 0.0 | 7,270.5 | 737.8 | 47.1 | 7,223.4 | 3,611.7 | 3,658.8 |
| 2019 | 8,348.1 | 0.0 | 8,348.1 | 563.3 | 0.0 | 0.0 | 0.0 | 7,784.8 | 0.0 | 0.0 | 0.0 | 0.0 | 7,784.8 | 693.6 | 44.3 | 7,740.5 | 3,870.3 | 3,914.5 |
| 2020 | 8,932.5 | 0.0 | 8,932.5 | 597.2 | 0.0 | 0.0 | 0.0 | 8,335.4 | 0.0 | 0.0 | 0.0 | 0.0 | 8,335.4 | 652.0 | 41.6 | 8,293.7 | 4,146.9 | 4,188.5 |
| 2021 | 9,557.8 | 0.0 | 9,557.8 | 633.0 | 0.0 | 0.0 | 0.0 | 8,924.8 | 0.0 | 0.0 | 0.0 | 0.0 | 8,924.8 | 612.8 | 39.1 | 8,885.7 | 4,442.8 | 4,482.0 |
| 2022 | 10,226.8 | 0.0 | 10,226.8 | 671.0 | 0.0 | 0.0 | 0.0 | 9,555.9 | 0.0 | 0.0 | 0.0 | 0.0 | 9,555.9 | 576.1 | 36.8 | 9,519.1 | 4,759.5 | 4,796.3 |
| 2023 | 10,942.7 | 0.0 | 10,942.7 | 711.2 | 0.0 | 0.0 | 0.0 | 10,231.5 | 0.0 | 0.0 | 0.0 | 0.0 | 10,231.5 | 541.5 | 34.6 | 10,196.9 | 5,098.5 | 5,133.0 |
| 2024 | 11,708.7 | 0.0 | 11,708.7 | 752.9 | 0.0 | 0.0 | 0.0 | 10,954.8 | 0.0 | 0.0 | 0.0 | 0.0 | 10,954.8 | 509.0 | 32.5 | 10,922.3 | 5,461.2 | 5,493.6 |
| 2025 | 12,526.3 | 0.0 | 12,526.3 | 797.1 | 0.0 | 0.0 | 0.0 | 11,729.2 | 0.0 | 0.0 | 0.0 | 0.0 | 11,729.2 | 478.5 | 30.5 | 11,698.6 | 5,849.3 | 5,879.9 |
| 2026 | 13,405.3 | 0.0 | 13,405.3 | 847.1 | 0.0 | 0.0 | 0.0 | 12,558.2 | 0.0 | 0.0 | 0.0 | 0.0 | 12,558.2 | 449.8 | 28.7 | 12,529.5 | 6,264.8 | 6,293.5 |
| 2027 | 14,343.7 | 0.0 | 14,343.7 | 897.9 | 0.0 | 0.0 | 0.0 | 13,445.8 | 0.0 | 0.0 | 0.0 | 0.0 | 13,445.8 | 422.8 | 27.0 | 13,418.8 | 6,709.4 | 6,736.4 |
| 2028 | 15,347.7 | 0.0 | 15,347.7 | 951.8 | 0.0 | 0.0 | 0.0 | 14,395.9 | 0.0 | 0.0 | 0.0 | 0.0 | 14,395.9 | 397.4 | 25.4 | 14,370.6 | 7,185.3 | 7,210.7 |
| 2029 | 16,422.1 | 0.0 | 16,422.1 | 1,008.9 | 0.0 | 0.0 | 0.0 | 15,413.2 | 0.0 | 0.0 | 0.0 | 0.0 | 15,413.2 | 373.6 | 23.8 | 15,389.3 | 7,694.7 | 7,718.5 |
| 2030 | 17,571.6 | 0.0 | 17,571.6 | 1,069.4 | 0.0 | 0.0 | 0.0 | 16,502.2 | 0.0 | 0.0 | 0.0 | 0.0 | 16,502.2 | 351.2 | 22.4 | 16,479.8 | 8,239.9 | 8,262.3 |
| 2031 | 18,801.6 | 0.0 | 18,801.6 | 1,133.6 | 0.0 | 0.0 | 0.0 | 17,668.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17,668.0 | 330.1 | 21.1 | 17,647.0 | 8,823.5 | 8,844.6 |
| 2032 | 20,117.7 | 0.0 | 20,117.7 | 1,201.6 | 0.0 | 0.0 | 0.0 | 18,916.1 | 0.0 | 0.0 | 0.0 | 0.0 | 18,916.1 | 310.3 | 19.8 | 18,896.3 | 9,448.1 | 9,468.0 |
| 2033 | 21,526.0 | 0.0 | 21,526.0 | 1,273.7 | 0.0 | 0.0 | 0.0 | 20,252.3 | 0.0 | 0.0 | 0.0 | 0.0 | 20,252.3 | 291.7 | 18.6 | 20,233.7 | 10,116.8 | 10,135.4 |
| 2034 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2035 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2036 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2037 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2038 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| PRESENT VALUES OF CASH FLOWS | 7,189.6 | 0.0 | 7,189.6 | 605.3 | 0.0 | 0.0 | 0.0 | 6,584.2 | 3,177.4 | | 2,878.2 | 1,017.4 | 2,394.3 | | 1,390.0 | 2,316.0 | 1,158.0 | 1,236.3 |



IMPACT OF WATER RENT ON
QUANTITY OF FEASIBLE ON-GRID POWER

FIGURE 4.2



IMPACT OF REQUIRED RATE OF RETURN
ON QUANTITY OF FEASIBLE ON-GRID POWER

FIGURE 4.3

## TABLE 4.2

## FINANCIAL FEASIBILITY OF SMALL HYDRO POWER FOR ALTERNATIVE POLICIES
(Quantity of Energy in GW.h per year)

| Water Rent | | School Tax Assessment Ratio | First Year of Non-Negative Pre-Tax Cashflow | Price of Power at Grid (Mills) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Per kW.h | Per kW.h | | | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| 2.50 | 5.00 | 35% | 2 | 0 | 0 | 149 | 282 | 590 | 919 | 1,267 |
| 2.50 | 5.00 | 35% | 4 | 0 | 0 | 170 | 412 | 892 | 1,195 | 1,594 |
| 2.50 | 0 | 35% | 2 | 0 | 0 | 170 | 315 | 672 | 930 | 1,290 |
| 2.50 | 0 | 35% | 4 | 0 | 129 | 170 | 539 | 919 | 1,337 | 1,659 |
| 0 | 0 | 35% | 2 | 0 | 129 | 170 | 412 | 870 | 1,124 | 1,506 |
| 0 | 0 | 35% | 4 | 0 | 170 | 315 | 854 | 1,115 | 1,506 | 1,960 |
| 0 | 0 | 20% | 2 | 0 | 149 | 282 | 637 | 938 | 1,439 | 1,684 |
| 0 | 0 | 20% | 4 | 0 | 170 | 446 | 919 | 1,429 | 1,684 | 2,108 |
| 0 | 0 | 0% | 2 | 0 | 170 | 432 | 872 | 1,337 | 1,659 | 2,085 |
| 0 | 0 | 0% | 4 | 129 | 315 | 870 | 1,245 | 1,659 | 2,108 | 2,659 |

There are many possible variations. For example the tax holiday could be granted, but only during the first 10 years of a project, possibly with provision for increased tax rates in later years to recapture the losses. Relaxation of most of the water rent and school tax might be required but provision should be made for adjusting the level of exemption as required. It is recommended that further study be devoted to exploring the options.

## Auctioning of Water Rights

Granting of blanket tax concessions to all small hydro power developments is likely to make the best sites highly profitable if water licences were offered at a flat rate. This could result in a 'gold rush' to stake out likely sites and a flood of water licence applications which could overload approving agencies. Probably it would be better if a mechanism were established to ensure the orderly development of the resource and the capture of as much of its value as possible for the public purse.

It is proposed that water licences be made available as required by some type of public auction. Thus competition could ensure that excessive profits did not accrue to developers, and that an economically efficient price is charged for water rights. It could also allow the early recapture of tax concessions to the maximum extent possible. For example, an exemption from the water tax would result in higher cash flows to the prospective developers of a site. They could therefore pay more for the right to develop it. Competition for the right to develop the site would result in bids that at least partially recapture the present value of the tax concession. Furthermore the bidding process should help to ensure that sites are developed to their full potential since developers proposing to build an optimally sized plant should be able to out-bid others.

Table 4.3 shows the possible impact of these policies on the feasibility of the resource. The auction value of the resource in the column on the right is the residual present value of the prices developers could pay for all feasible sites under those conditions and still earn the overall rate of return indicated.

It is presumed that the initial developers of sites under this scenario will require a relatively high rate of return. This will be necessary to eliminate the early negative cash flows and to provide an incentive for undertaking a new type of venture. Thus bid prices will be relatively low. As these developments become more familiar, more appropriate financing should become available and target rates of return might drop resulting in increased bid prices. Figure 4.3 shows the impact of the rate of return required by the developer on the supply of small hydro power.

Assuming a 19 percent return for the early projects and a 35 mill price it can be seen from Table 4.3 that 930 GW.h per year of power would be feasible if both school tax and water rent were eliminated. This could generate up to $105 million of revenue from auctioning the 29 feasible sites. If the rate of return were dropped to 17 percent the amount of power would be 1337 GW.h per year and the revenue could be $137 million. This is about the amount of power that was indicated as desirable by the economic study. In the event that the accelerated federal tax write-off was extended then more power than is necessary would result, and the revenue from water licence sales would probably be higher.

A disadvantage of the auction approach is that it requires a relatively high level of involvement by the government in selecting sites for development. The resource could also be developed by the more passive approach of soliciting proposals from prospective developers who seek out sites they wish to develop. Appropriate phasing of development could still be achieved by only granting enough water licences to meet forecasted requirements at a given time. The advantage of this approach is that it is relatively simple. A disadvantage is that it does not generate the revenue that could come from an auction, and some other mechanism would be required to ensure the optimal level of development.

# TABLE 4.3 - IMPACT OF ELIMINATING WATER RENT AND/OR SCHOOL TAX

| Rate of Return for Developer | Water Rent Paid | School Tax Paid | Capital Cost Allowance | Number of Feasible Sites | Amount of Energy (GW.h/Yr) | Total Residual Value of Feasible Sites (Auction Value) ($1,000) |
|---|---|---|---|---|---|---|
| 15 | Yes | Yes | All 6% | 28 | 919 | 29,243 |
| 17 | Yes | Yes | | 19 | 652 | 12,880 |
| 19 | Yes | Yes | | 8 | 358 | 6,164 |
| 15 | No | Yes | All 6% | 39 | 1,115 | 40,782 |
| 17 | No | Yes | | 26 | 870 | 20,272 |
| 19 | No | Yes | | 16 | 590 | 9,569 |
| 15 | No | No | All 6% | 70 | 1,678 | 184,824 |
| 17 | No | No | | 53 | 1,337 | 137,201 |
| 19 | No | No | | 29 | 930 | 105,796 |
| 15 | Yes | Yes | All Accelerated | 142 | 2,850 | 151,064 |
| 17 | Yes | Yes | | 135 | 2,754 | 110,778 |
| 19 | Yes | Yes | | 129 | 2,696 | 84,590 |
| 15 | No | Yes | All Accelerated | 153 | 1,678 | 78,677 |
| 17 | No | Yes | | 149 | 1,337 | 40,897 |
| 19 | No | Yes | | 146 | 930 | 21,877 |
| 15 | No | No | All Accelerated | 285 | 4,239 | 322,383 |
| 17 | No | No | | 274 | 4,153 | 241,726 |
| 19 | No | No | | 262 | 4,069 | 188,092 |

**Assumptions**

All as Table 3.5

Assumes average price of power is 35 mills.

## 5. CONCLUSIONS AND RECOMMENDATIONS

1. The small hydro power resource represents a significant potential source of power. About 1370 GW.h per year of energy from 54 sites could be generated for supply to the integrated grid at a cost lower than Peace Site C. This is about 29 percent of the output that would be available from Peace Site C, and is probably enough to meet about 2 to 3 years of British Columbia load growth. The average economic cost of this power over all sites would be about 27 mills compared to the cost of Peace Site C which is 35 mills.

2. The majority of the economically feasible on-grid small hydro power resource is located in the Southwest Coast or on Vancouver Island (75 percent). About 17 percent is located in the Interior while only about 8 percent is in the North Coast region.

3. Small hydro power is more flexible in meeting demand growth than large scale hydro power because it requires a shorter lead time for development and can be developed in smaller increments. Also less environmental problems and costs may be anticipated.

4. The net economic benefit of deferring the development of a typical large hydro power project (Peace Site C) by first developing all lower cost small hydro power is about $36 million. This is comprised of about $23 million due to a better matching of demand with supply, and $13 million due to the lower average cost of this block of small hydro power.

5. The financial feasibility of private sector development of small hydro power is very sensitive to factors such as the purchase price of power, the assumed rate of inflation of power prices, the rate of return required by the developer, the tax situation of the developer and the availability of appropriate debt financing. In the most likely financial scenario, a power price of almost 40 mills would be required to encourage private sector development of the economically desirable amount of small hydro power.

6. The currently available federal government accelerated capital cost allowance (Class 34) tax concession for alternative energy sources can greatly increase the amount of financially feasible small hydro power. If all developers of small hydro power projects were assumed to fully take advantage of it, the economically desirable amount of power could be available for a price of under 30 mills. It is scheduled to expire in 1985 which is before most on-grid small hydro power should be developed, but the possibility of an extension exists.

7. Developers of small hydro power will likely have difficulty obtaining debt financing through conventional capital markets assuming no special policies are enacted to deal with the problem. The main reason for the difficulty of financing is that small hydro power projects are capital-intensive resulting in relatively high debt payments in the early years and thus negative pre-tax cash flows. As financial institutions become more familiar with small hydro power development, appropriate financing mechanisms may evolve.

8. The price that B C Hydro pays for power should be based on its incremental cost of providing additional energy generating capacity.

9. The Provincial Government should adopt a policy in respect of the small hydro power resource such that the economically feasible sites are developed at the appropriate time to meet future needs for power. Alternatively, small hydro power development at an earlier time may free up additional firm power for export purposes, and will also serve as demonstration projects or prototypes.

10. Additional incentives should be considered for the development of the small hydro power resource, located in power short areas, diesel areas and developing areas, whereby some infrastructure costs may be avoided.

## REFERENCES

(1) SIGMA ENGINEERING LTD: **Small Hydro Power Resource in the Provincial System, Technology and Resource Assessment**; Ministry of Energy, Mines and Petroleum Resources, British Columbia, July 1983.

(2) ENERGY, MINES AND RESOURCES CANADA (CRIPPEN CONSULTANTS): **Microhydro, A Survey of Potential Micro Hydro Developments for Use By Small Communities in British Columbia,** October 1980.

(3) MATT HERRON, SMITHSONIAN: **The Rush is on to Find New Gold in Falling Water**, November 1982.

(4) B C HYDRO: **1982 Ten Year Electric System Plans and Evaluations (Summary Outline) 1 April, 1982 to 31 March, 1992**, Vancouver BC, December 1981.

(5) B C HYDRO: **Marginal Cost Study (Draft)**, Vancouver BC, December 1982.

(6) MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES: **British Columbia Energy Supply and Requirements Forecast 1980 - 1995**, Victoria BC, 1981.

(7) ALTA, INC: **Potential Markets in the Pacific Northwest and California for Surplus Electricity from British Columbia,** for the BC Utilities Commission, Seattle, Washington, November 1981.

(8) PACIFIC GAS AND ELECTRIC COMPANY: **Generation-Related Avoided Costs**, Testimony of G S Fiske in PGE Application No 82-03-26 in OIR-2.

(9) B C HYDRO: **Customer Owned Generation of Electricity**, Policy Document EOI B17-1, Vancouver B C.

(10) B C UTILITIES COMMISSION: **Summary of Projections of Electric and Gas Gross Load Requirements**, Victoria B C, September 1982.

(11) REVENUE CANADA: Class 34, Income Tax Regulations, Accelerated Capital Cost Allowance and Interpretation Bulletin IT - 147R.

(12) ENERGY MINES AND RESOURCES CANADA (SIGMA ENGINEERING LTD): Remote Community Demonstration Program, Overview Study for British Columbia (Draft), May 1983.

# APPENDIX 1

# APPENDIX 1

## CHARACTERISTICS AND COSTS OF SITES WITH POWER COSTING LESS THAN 100 MILLS AT THE GRID

**Assumptions:**

1. Costs are based on the same methodology as described in Appendix 2 and Appendix 4.

2. Sites are sorted in order of cost per kW.h as delivered to the grid.

3. Sites with "N/A" in the distance to grid column are suitable only for off-grid use.

4. The reader is referred to the Resource Assessment (Reference 1)for more details of the sites.

## ECONOMIC COST OF POWER FOR ALL SITES COSTING LESS THAN 10.0 CENTS PER KWH.
(Sorted according to cost)

| NAME | LATITUDE | LONGITUDE | CAPACITY (kw) | COST/KWH (cents) | TRANSMISSION DISTANCE (km) |
|---|---|---|---|---|---|
| BROWN CR | 54 02 | 129 50 | 4660 | 1.7 | N/A |
| MAMQUAM CR | 49 43 | 123 04 | 28700 | 1.8 | 6.0 |
| CERVUS CR | 49 51 | 125 47 | 3900 | 2.0 | 1.6 |
| UNNAMED CR | 49 45 | 123 31 | 4800 | 2.0 | 6.0 |
| ASHLU CR | 49 55 | 123 20 | 20500 | 2.3 | 5.0 |
| JOFFRE CR | 49 18 | 122 35 | 5200 | 2.3 | 10.0 |
| HUNLEN CR | 52 17 | 125 45 | 10500 | 2.3 | N/A |
| HIGH FALLS | 49 56 | 123 18 | 7300 | 2.4 | 1.0 |
| THORNHILL | 49 40 | 123 36 | 3970 | 2.5 | 0.0 |
| FURRY CR | 49 35 | 123 13 | 5800 | 2.5 | 6.0 |
| ZEBALLOS(L | 49 59 | 126 45 | 2300 | 2.5 | N/A |
| TIPELLA CR | 49 45 | 122 10 | 3200 | 2.6 | 0.0 |
| SECHELT CR | 49 40 | 123 33 | 6600 | 2.6 | 0.5 |
| WEDGE CR | 50 10 | 122 54 | 5500 | 2.6 | 2.0 |
| PERKETTS C | 49 53 | 123 52 | 4500 | 2.6 | 15.0 |
| KOKISH R | 50 31 | 126 52 | 12000 | 2.7 | 0.5 |
| KHTADA CR | 54 11 | 129 36 | 6690 | 2.7 | 0.5 |
| TWENTYONE | 50 07 | 122 59 | 2900 | 2.7 | 1.0 |
| TARUAT CR | 49 45 | 123 25 | 6700 | 2.7 | 11.0 |
| BIRKENHEAD | 50 20 | 122 43 | 5100 | 2.8 | 1.0 |
| ROGERS CR | 49 59 | 122 27 | 9100 | 2.8 | 1.0 |
| GWILLIM CR | 49 45 | 117 28 | 4200 | 2.8 | 1.0 |
| BIRKENHEAD | 50 27 | 122 41 | 6700 | 2.8 | 2.0 |
| CLARY CR | 55 28 | 129 27 | 6950 | 2.8 | 3.0 |
| UNNAMED CR | 52 55 | 118 53 | 3450 | 2.8 | 11.0 |
| YOUNG CR | 52 25 | 125 53 | 13000 | 2.8 | N/A |
| CACOOHTIN | 52 26 | 126 19 | 2590 | 2.8 | N/A |
| MILL CR | 52 24 | 126 34 | 4800 | 2.8 | N/A |
| RUBBLE CR | 49 57 | 123 07 | 14700 | 2.9 | 4.0 |
| SOUTH CRAN | 50 46 | 118 06 | 3800 | 2.9 | 6.0 |
| UNNAMED CR | 49 45 | 123 27 | 3500 | 2.9 | 11.0 |
| UNNAMED CR | 50 01 | 123 21 | 3500 | 2.9 | 15.0 |
| MAYNARD I | 50 24 | 127 14 | 4190 | 3.0 | 18.0 |
| UCONA R | 49 44 | 125 57 | 2300 | 3.1 | 10.0 |
| UNNAMED CR | 52 56 | 118 53 | 6800 | 3.1 | 11.0 |
| MULVEHILL | 50 51 | 118 07 | 2000 | 3.2 | 0.5 |
| ROSEWALL C | 49 27 | 124 48 | 7100 | 3.2 | 1.0 |
| MAWBY CR | 49 53 | 123 18 | 2700 | 3.2 | 2.0 |
| KLEANZA CR | 54 36 | 128 22 | 6060 | 3.2 | 2.0 |
| AIRPLANE C | 49 08 | 121 37 | 2000 | 3.2 | 7.0 |
| MOOSE R | 52 55 | 118 48 | 6800 | 3.2 | 15.0 |
| TASTSQUAN | 52 22 | 126 45 | 1200 | 3.2 | N/A |
| McDONALD C | 54 07 | 129 54 | 2600 | 3.3 | 0.5 |
| McGILLIVAR | 50 37 | 122 26 | 2900 | 3.3 | 1.0 |
| URE CR | 50 16 | 122 35 | 11800 | 3.3 | 10.0 |
| BROWNS R & | 49 41 | 125 09 | 2100 | 3.3 | 2.1 |
| MONMOUTH C | 49 43 | 123 11 | 2040 | 3.4 | 3.0 |
| CHIPMUNK C | 49 06 | 121 39 | 6500 | 3.4 | 3.0 |
| UNNAMED CR | 50 57 | 118 24 | 2500 | 3.4 | 6.0 |
| KAIPIT CR | 50 15 | 126 48 | 4200 | 3.4 | 6.0 |
| OWL CR | 50 22 | 122 44 | 2400 | 3.4 | 1.0 |
| LOST VALLE | 50 40 | 122 18 | 2300 | 3.4 | 6.0 |
| NICOAMEN C | 50 16 | 121 24 | 2200 | 3.4 | 10.0 |
| CRUICKSHAN | 49 36 | 125 15 | 5800 | 3.4 | 18.0 |
| CHICKWAT C | 49 49 | 123 43 | 4800 | 3.4 | 27.0 |
| ARDEN CR | 54 19 | 129 41 | 2900 | 3.4 | N/A |

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| BOX CANYON | 49 35 | 123 24 | 2100 | 3.5 | 2.0 |
| UNNAMED CR | 49 47 | 123 34 | 4600 | 3.5 | 17.0 |
| UNNAMED CR | 49 43 | 123 45 | 3200 | 3.5 | 17.0 |
| HIGH CR | 49 55 | 123 52 | 3300 | 3.5 | 21.0 |
| ELAHO CR | 50 07 | 123 26 | 19400 | 3.5 | 27.0 |
| HANDY CR | 49 00 | 124 56 | 2700 | 3.5 | 29.0 |
| NOOKLIKONN | 52 22 | 126 34 | 4480 | 3.5 | N/A |
| TSABLE R | 49 31 | 124 54 | 2400 | 3.6 | 4.0 |
| BEATRICE C | 49 50 | 117 28 | 4900 | 3.6 | 7.0 |
| CAMERON R | 49 15 | 124 40 | 2200 | 3.6 | 9.0 |
| PIGGOTT CR | 49 49 | 125 22 | 1900 | 3.6 | 14.0 |
| UNNAMED CR | 49 45 | 123 43 | 2340 | 3.6 | 18.0 |
| HADOW CR | 50 40 | 117 48 | 4200 | 3.6 | 41.0 |
| LIZZIE CR | 50 12 | 122 28 | 5700 | 3.7 | 1.0 |
| KWINATAHL | 55 25 | 129 08 | 6000 | 3.7 | 1.0 |
| CLAYTON FA | 52 22 | 126 49 | 2900 | 3.7 | N/A |
| SNOOTLI CR | 52 23 | 126 36 | 2420 | 3.7 | N/A |
| UNNAMED CR | 49 44 | 123 32 | 1300 | 3.8 | 5.0 |
| UNNAMED CR | 49 46 | 123 26 | 2090 | 3.8 | 14.0 |
| BEAR CR | 49 28 | 121 46 | 4100 | 3.8 | 20.0 |
| TSEAPSEAHO | 52 26 | 126 24 | 2470 | 3.8 | N/A |
| UNNAMED CR | 52 10 | 126 50 | 3500 | 3.8 | N/A |
| SMITELY R | 52 07 | 126 39 | 6500 | 3.8 | N/A |
| KUSHANAX C | 50 16 | 117 46 | 6300 | 3.9 | 0.0 |
| FRIES CR | 49 45 | 123 09 | 2000 | 3.9 | 3.0 |
| SIWASH CR | 49 34 | 121 24 | 4200 | 3.9 | 12.0 |
| CLOWHOM R | 49 50 | 123 29 | 3800 | 3.9 | 27.0 |
| FALL CR | 50 36 | 118 53 | 1700 | 4.0 | 1.5 |
| WHITE R | 50 18 | 125 56 | 6300 | 4.0 | 2.0 |
| CARIBOU CR | 49 59 | 117 50 | 5300 | 4.0 | 2.5 |
| KOKISH R | 50 27 | 126 47 | 4700 | 4.0 | 3.0 |
| WEE SANDY | 50 00 | 117 25 | 2300 | 4.0 | 10.0 |
| UNNAMED CR | 52 54 | 118 46 | 2700 | 4.0 | 24.0 |
| McDONALD C | 50 34 | 116 25 | 3100 | 4.0 | 28.0 |
| KELSKIIST | 55 21 | 129 42 | 4500 | 4.0 | 28.0 |
| JANET CR | 52 23 | 125 52 | 4100 | 4.0 | N/A |
| SICAMOUS C | 50 48 | 118 58 | 2300 | 4.1 | 0.0 |
| STAWAMUS C | 49 42 | 123 07 | 5500 | 4.1 | 3.0 |
| McKELVIE C | 49 56 | 126 39 | 1580 | 4.1 | 4.0 |
| KWOIEK CR | 50 07 | 121 35 | 18600 | 4.1 | 7.0 |
| GRAY CR | 49 32 | 123 45 | 2490 | 4.1 | 8.0 |
| SHAW CR | 49 15 | 116 43 | 1900 | 4.1 | 17.0 |
| UNNAMED CR | 49 46 | 125 41 | 3500 | 4.1 | 20.0 |
| CLINT CR | 50 13 | 116 54 | 4200 | 4.2 | 1.0 |
| NORDSCHOW | 52 18 | 126 03 | 3790 | 4.2 | N/A |
| SPUZZUM CR | 49 39 | 121 26 | 2600 | 4.3 | 2.0 |
| WILSON CR | 50 08 | 117 20 | 3900 | 4.3 | 11.0 |
| UNNAMED CR | 54 20 | 129 46 | 2000 | 4.3 | 16.0 |
| UNNAMED CR | 49 49 | 123 23 | 2200 | 4.3 | 17.0 |
| FOSTHALL C | 50 22 | 117 57 | 3900 | 4.3 | 34.0 |
| COGBURN CR | 49 33 | 121 45 | 4200 | 4.3 | 35.0 |
| THOMAS LAK | 49 36 | 122 25 | 4100 | 4.3 | 50.0 |
| UNNAMED CR | 52 01 | 126 32 | 6280 | 4.3 | N/A |
| McNAIR CR | 49 31 | 123 30 | 2800 | 4.4 | 1.0 |
| TANTALUS C | 49 51 | 123 15 | 4900 | 4.4 | 2.0 |
| DAHL CR | 54 09 | 128 43 | 1580 | 4.4 | 10.0 |
| TEXAS CR | 50 34 | 121 49 | 2700 | 4.4 | 18.0 |
| BROWNS R # | 49 42 | 125 08 | 2300 | 4.5 | 2.0 |
| LADYBIRD C | 49 25 | 117 40 | 1780 | 4.5 | 2.5 |
| McLENNON R | 52 51 | 119 21 | 2500 | 4.5 | 6.0 |

| | | | | | |
|---|---|---|---|---|---|
| BREMNER CR | 49 40 | 122 01 | 1400 | 4.5 | 7.0 |
| CLOWHOM R | 49 49 | 123 23 | 3400 | 4.5 | 19.0 |
| BOISE CR | 49 37 | 122 41 | 9300 | 4.5 | 50.0 |
| CYPRESS CR | 49 20 | 123 14 | 1000 | 4.6 | 0.0 |
| LOFTUS CR | 50 56 | 118 49 | 1350 | 4.6 | 0.5 |
| UNNAMED CR | 49 41 | 123 16 | 1770 | 4.6 | 2.5 |
| TSUIUS CR | 50 37 | 118 40 | 5300 | 4.6 | 7.0 |
| RED TUSK C | 49 47 | 123 25 | 3300 | 4.6 | 13.0 |
| SQUAMISH R | 50 10 | 123 24 | 11400 | 4.6 | 30.0 |
| MASELPANIK | 49 07 | 121 15 | 5100 | 4.6 | 37.0 |
| FISH HATCH | 49 36 | 122 38 | 5200 | 4.6 | 30.0 |
| NOFICK R | 52 05 | 126 34 | 12200 | 4.6 | N/A |
| SANCA CR | 49 23 | 116 43 | 2000 | 4.7 | 1.0 |
| CALLAGHAN | 50 04 | 123 06 | 7000 | 4.7 | 2.0 |
| ANDERSON C | 49 11 | 121 43 | 1300 | 4.7 | 5.0 |
| VICTOR CR | 50 57 | 118 24 | 1100 | 4.7 | 6.0 |
| CAYOOSH CR | 50 39 | 122 01 | 7000 | 4.7 | 7.0 |
| LAKE LOVEL | 49 48 | 123 13 | 5900 | 4.7 | 9.0 |
| GOLD CR | 49 21 | 122 27 | 1900 | 4.7 | 16.0 |
| BIG SILVER | 49 42 | 121 51 | 9500 | 4.7 | 50.0 |
| ZEBALLOS L | 50 03 | 126 46 | 3500 | 4.7 | N/A |
| UNNAMED CR | 50 55 | 118 07 | 1500 | 4.7 | N/A |
| RAINY R | 49 32 | 123 30 | 3070 | 4.8 | 3.0 |
| GOAT CR | 54 43 | 128 46 | 1120 | 4.8 | 4.0 |
| SALMON R | 50 05 | 126 41 | 2700 | 4.8 | 19.0 |
| NEXT CR | 49 18 | 116 45 | 3000 | 4.8 | 22.0 |
| ROARING CR | 49 27 | 122 13 | 2000 | 4.8 | 25.0 |
| EAST CR #2 | 50 39 | 117 01 | 5000 | 4.8 | 40.0 |
| UNNAMED CR | 52 10 | 126 50 | 8400 | 4.8 | N/A |
| TSINI-TSIN | 52 22 | 126 06 | 1790 | 4.8 | N/A |
| YARD CR | 50 54 | 118 48 | 3290 | 4.9 | 0.0 |
| LASCA CR | 49 36 | 117 09 | 3200 | 4.9 | 1.0 |
| KOOKIPI CR | 49 59 | 121 38 | 11600 | 4.9 | 12.0 |
| WRAY CR | 49 20 | 121 18 | 1800 | 4.9 | 12.0 |
| WADY CR | 50 24 | 127 17 | 1500 | 4.9 | 16.0 |
| GRANT BROO | 52 54 | 118 45 | 4200 | 4.9 | 21.0 |
| MOSHER CR | 52 25 | 125 58 | 3450 | 4.9 | N/A |
| NOOMST CR | 52 26 | 126 13 | 1430 | 4.9 | N/A |
| UNNAMED CR | 50 58 | 118 36 | 1100 | 5.0 | 7.0 |
| BOWBYES CR | 54 09 | 128 42 | 1230 | 5.0 | 8.0 |
| DAVE HENRY | 52 45 | 119 05 | 2300 | 5.0 | 11.0 |
| CASCADE R | 56 03 | 130 02 | 1800 | 5.0 | 17.0 |
| CRAWFORD C | 50 45 | 117 59 | 1900 | 5.0 | 21.0 |
| THORSEN CR | 52 21 | 126 42 | 3500 | 5.0 | N/A |
| NOOMST CR | 52 23 | 126 15 | 4070 | 5.0 | N/A |
| TRETHEWAY | 49 42 | 122 05 | 1600 | 5.1 | 0.0 |
| WILLIAMS C | 54 24 | 128 25 | 3290 | 5.1 | 6.0 |
| SOWERBY CR | 49 19 | 121 26 | 4100 | 5.1 | 7.0 |
| CULLITON C | 49 53 | 123 09 | 6800 | 5.1 | 15.0 |
| KAIN CR | 50 51 | 116 35 | 1700 | 5.1 | 16.0 |
| HOTNARKO R | 52 23 | 125 45 | 8500 | 5.1 | N/A |
| BARNEY GUL | 55 57 | 129 58 | 1590 | 5.1 | N/A |
| BLURTON CR | 50 41 | 119 02 | 1400 | 5.2 | 1.0 |
| UNNAMED CR | 49 50 | 121 31 | 4300 | 5.2 | 9.0 |
| CLEMINA CR | 52 34 | 119 05 | 2700 | 5.2 | 10.0 |
| TOMMY CR | 50 50 | 122 31 | 2500 | 5.2 | 20.0 |
| UNNAMED CR | 50 59 | 116 45 | 2000 | 5.2 | 28.0 |
| ZEBALLOS R | 50 03 | 126 47 | 2400 | 5.2 | N/A |
| MARMOT R | 55 53 | 130 00 | 2460 | 5.2 | N/A |
| SAUNDERS C | 49 48 | 126 01 | 2000 | 5.3 | 2.0 |

| | | | | | |
|---|---|---|---|---|---|
| TRUAX CR | 50 53 | 122 38 | 1400 | 5.3 | 16.0 |
| UNNAMED CR | 49 57 | 121 50 | 5300 | 5.3 | 28.0 |
| ATNARKO R | 52 10 | 125 42 | 20000 | 5.3 | N/A |
| WRAGGE CR | 50 04 | 117 28 | 1990 | 5.4 | 2.0 |
| DRUMMIE CR | 50 52 | 118 05 | 1300 | 5.4 | 7.0 |
| UNNAMED CR | 49 48 | 123 24 | 4280 | 5.4 | 15.0 |
| EATON CR | 49 15 | 121 23 | 1900 | 5.4 | 16.0 |
| UNNAMED CR | 52 21 | 126 10 | 2800 | 5.4 | N/A |
| MOLYBDDDEN | 54 34 | 128 45 | 1090 | 5.5 | 8.5 |
| CHIMDEMASH | 54 40 | 128 22 | 3950 | 5.6 | 0.0 |
| WHITECAP C | 50 43 | 122 18 | 1050 | 5.6 | 1.0 |
| SHANNON CR | 50 05 | 117 29 | 1900 | 5.6 | 2.0 |
| UNNAMED CR | 50 10 | 126 20 | 1300 | 5.6 | 13.0 |
| McKAY CR | 54 13 | 128 25 | 5370 | 5.6 | 18.0 |
| BULLDOG CR | 52 39 | 118 59 | 3900 | 5.6 | 26.0 |
| SWIFTCURRE | 53 01 | 119 17 | 2550 | 5.8 | 0.5 |
| LEINER R | 49 56 | 126 37 | 1700 | 5.8 | 4.0 |
| POST CR | 49 05 | 121 28 | 1020 | 5.8 | 17.0 |
| UNNAMED CR | 54 27 | 130 04 | 1180 | 5.8 | 30.0 |
| UNNAMED CR | 50 29 | 122 22 | 1500 | 5.9 | 8.0 |
| SEDAN CR | 55 05 | 128 12 | 2030 | 5.9 | 8.0 |
| UNNAMED CR | 54 11 | 129 45 | 1300 | 5.9 | 10.0 |
| UNNAMED CR | 54 05 | 129 56 | 820 | 5.9 | 12.0 |
| BERNARD CR | 49 52 | 116 51 | 2200 | 5.9 | 20.0 |
| GOLD R | 49 52 | 126 06 | 4400 | 5.9 | 4.4 |
| MONTAGUE C | 50 20 | 126 12 | 2400 | 5.9 | 22.0 |
| LAFORGUE C | 49 14 | 121 09 | 1300 | 5.9 | 27.0 |
| PHILLIPS C | 49 40 | 125 34 | 2800 | 5.9 | 27.0 |
| GHITA CR | 52 51 | 113 39 | 5800 | 5.9 | 31.0 |
| COLONEL JO | 54 13 | 130 09 | 610 | 5.9 | N/A |
| HILLS CR | 50 43 | 119 04 | 1200 | 6.0 | 3.0 |
| EAST TWIN | 53 28 | 120 23 | 1720 | 6.0 | 22.0 |
| CLOWHOM R | 49 51 | 123 27 | 3100 | 6.0 | 25.0 |
| SMITELY R | 52 05 | 126 36 | 4100 | 6.0 | N/A |
| HEADQUARTE | 49 42 | 125 07 | 540 | 6.1 | 1.4 |
| SCUZZZY CR | 49 49 | 121 28 | 3900 | 6.1 | 3.0 |
| SOUTH ENGL | 49 15 | 124 17 | 3300 | 6.1 | 5.0 |
| WILSON CR | 49 35 | 116 52 | 2500 | 6.1 | 12.0 |
| HORSEY CR | 53 08 | 119 41 | 5150 | 6.1 | 14.0 |
| UNNAMED CR | 54 23 | 128 53 | 1800 | 6.1 | 15.0 |
| UNNAMED CR | 49 55 | 123 48 | 3650 | 6.1 | 25.0 |
| VANCOUVER | 49 56 | 123 48 | 3500 | 6.1 | 25.0 |
| UNNAMED CR | 49 40 | 123 35 | 1140 | 6.2 | 0.0 |
| MARA CR | 50 46 | 119 00 | 850 | 6.2 | 1.0 |
| CASCADE CR | 50 25 | 117 07 | 2500 | 6.2 | 4.5 |
| STE CROIX | 54 42 | 128 19 | 1490 | 6.2 | 6.0 |
| HARDSCRABB | 54 42 | 128 20 | 1270 | 6.2 | 8.0 |
| CAYOOSH CR | 50 39 | 121 59 | 4620 | 6.3 | 1.0 |
| NEMO CR | 49 55 | 117 25 | 7100 | 6.3 | 3.0 |
| LATEWHOS C | 50 27 | 118 43 | 2100 | 6.3 | 8.0 |
| TZOONIE CR | 49 47 | 123 43 | 2400 | 6.3 | 23.0 |
| WARREN CR | 50 58 | 116 42 | 5500 | 6.3 | 24.0 |
| POOL CR | 50 47 | 117 38 | 6200 | 6.3 | 31.0 |
| CADWALLADE | 50 46 | 122 48 | 1700 | 6.4 | 0.5 |
| LEGERWOOD | 50 58 | 118 46 | 950 | 6.4 | 1.5 |
| CHUA CHUA | 51 21 | 120 07 | 1500 | 6.4 | 2.0 |
| SEASKINNIS | 55 16 | 128 59 | 2330 | 6.4 | 2.0 |
| UNNAMED CR | 50 07 | 126 36 | 1400 | 6.4 | 9.0 |
| DORE R #1 | 53 16 | 120 17 | 4450 | 6.4 | 13.0 |
| WALT LAKE | 49 53 | 124 08 | 750 | 6.4 | 16.0 |

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| CRAFT CR | 50 24 | 127 15 | 1500 | 6.4 | 18.0 |
| THELWOOD C | 49 33 | 125 34 | 2100 | 6.4 | 41.0 |
| TWIN ONE C | 50 15 | 122 30 | 6900 | 6.5 | 1.0 |
| TLOOLS CR | 49 52 | 125 45 | 1070 | 6.5 | 1.0 |
| UNNAMED CR | 49 29 | 121 25 | 1300 | 6.5 | 3.0 |
| CHASE CR | 50 49 | 119 41 | 700 | 6.6 | 0.0 |
| COOKE CR | 50 37 | 118 50 | 2700 | 6.6 | 0.5 |
| LOST LEDGE | 50 06 | 116 56 | 860 | 6.6 | 0.5 |
| DAVIS CR | 50 08 | 116 57 | 680 | 6.6 | 0.5 |
| NABEELAH C | 54 08 | 128 32 | 920 | 6.6 | 6.0 |
| NEWCASTLE | 50 22 | 126 07 | 1300 | 6.6 | 15.0 |
| YELLOWJACK | 52 43 | 119 03 | 1400 | 6.6 | 17.0 |
| GIEGERICH | 50 43 | 117 07 | 3300 | 6.6 | 55.0 |
| SCHROEDER | 50 02 | 116 55 | 1400 | 6.7 | 0.5 |
| UNNAMED CR | 50 30 | 126 54 | 620 | 6.7 | 1.6 |
| CLUTE CR | 50 01 | 116 53 | 3500 | 6.7 | 8.0 |
| UNNAMED CR | 49 41 | 123 35 | 1100 | 6.7 | 8.0 |
| TAM O'SHAN | 49 48 | 116 51 | 3400 | 6.7 | 3.0 |
| McNULTY CR | 49 25 | 120 05 | 2200 | 6.7 | 10.0 |
| TEMPLETON | 50 48 | 116 29 | 1800 | 6.7 | 21.0 |
| DERRY CR | 50 46 | 118 33 | 2800 | 6.7 | 22.0 |
| HALFWAY HO | 50 29 | 117 51 | 5700 | 6.7 | 22.0 |
| CULTUS CR | 49 20 | 116 47 | 3400 | 6.7 | 25.0 |
| UNNAMED CR | 49 09 | 121 15 | 1570 | 6.7 | 30.0 |
| EAST CR #1 | 50 39 | 117 02 | 2500 | 6.7 | 38.0 |
| BEATTON CR | 50 44 | 117 44 | 3000 | 6.7 | 46.0 |
| UNNAMED CR | 49 40 | 121 51 | 2500 | 6.7 | 55.0 |
| KELLIE CR | 50 55 | 117 34 | 3100 | 6.7 | 65.0 |
| NOEL CR | 50 46 | 122 48 | 1160 | 6.8 | 2.0 |
| ROBSON R | 53 03 | 119 13 | 2690 | 6.8 | 2.5 |
| KOKISH R | 50 28 | 126 48 | 2390 | 6.8 | 2.8 |
| WILFRED CR | 49 28 | 124 51 | 540 | 6.8 | 3.5 |
| WHITE CR | 54 24 | 128 41 | 1390 | 6.8 | 8.0 |
| LOKI CR | 49 50 | 116 51 | 2600 | 6.8 | 14.0 |
| POWDER CR | 49 53 | 116 51 | 3600 | 6.8 | 23.0 |
| UNNAMED CR | 49 09 | 121 20 | 2000 | 6.8 | 30.0 |
| UNNAMED CR | 50 29 | 127 21 | 770 | 6.9 | 10.0 |
| EDDY CR | 53 14 | 120 07 | 1070 | 6.9 | 10.0 |
| CAMPBELL C | 49 57 | 116 51 | 4800 | 6.9 | 12.0 |
| SHANNON CR | 54 40 | 127 30 | 1300 | 6.9 | 17.0 |
| NORA CR | 50 08 | 126 02 | 1200 | 6.9 | 22.0 |
| MOAKWA CR | 50 07 | 126 02 | 2000 | 6.9 | 22.0 |
| UNNAMED CR | 53 08 | 120 01 | 2240 | 6.9 | 23.0 |
| BURMAN R | 49 36 | 125 50 | 1600 | 6.9 | 26.0 |
| SACHS CR | 53 12 | 131 58 | 780 | 6.9 | N/A |
| ALICE CR | 54 40 | 128 47 | 1250 | 7.0 | 1.8 |
| CHEEKYE R | 49 48 | 123 06 | 1400 | 7.0 | 7.0 |
| MUCHALAT R | 49 53 | 126 19 | 880 | 7.0 | 12.0 |
| COMOX CR | 49 32 | 125 15 | 720 | 7.0 | 18.0 |
| RAPID CR | 50 27 | 117 10 | 2500 | 7.0 | 21.0 |
| TLATLOS CR | 50 23 | 126 14 | 2700 | 7.0 | 26.0 |
| LYNN CR | 49 21 | 123 01 | 2100 | 7.1 | 0.0 |
| CONNEL CR | 50 39 | 122 25 | 4400 | 7.1 | 0.5 |
| MARUILLA C | 50 05 | 126 25 | 2200 | 7.1 | 0.8 |
| UNNAMED CR | 50 10 | 126 18 | 940 | 7.1 | 14.0 |
| CATHERINE | 50 25 | 126 36 | 1970 | 7.1 | 19.0 |
| UNNAMED CR | 49 12 | 121 20 | 1300 | 7.1 | 24.0 |
| AMERICAN C | 56 08 | 129 54 | 3340 | 7.1 | 25.0 |
| MESS CR | 57 53 | 131 12 | 10300 | 7.1 | N/A |
| CAMP CR | 52 39 | 119 11 | 1700 | 7.2 | 2.0 |

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| ENGLISHMAN | 49 15 | 124 21 | 3700 | 7.2 | 2.3 |
| MACKTUSH C | 49 06 | 124 51 | 1000 | 7.2 | 10.0 |
| BOYD CR | 50 53 | 117 34 | 4000 | 7.2 | 64.0 |
| NOOSGULCH | 52 26 | 126 23 | 1800 | 7.2 | N/A |
| HUMMING BI | 50 46 | 119 00 | 550 | 7.3 | 1.0 |
| BUTTERWORT | 49 48 | 125 53 | 950 | 7.3 | 6.3 |
| SMALL CR | 53 04 | 119 35 | 4000 | 7.3 | 7.0 |
| DORE R #2 | 53 13 | 120 17 | 3420 | 7.3 | 17.0 |
| UNNAMED CR | 49 15 | 121 15 | 1200 | 7.3 | 25.0 |
| GLACIER CR | 55 59 | 129 56 | 1270 | 7.3 | N/A |
| REINECKER | 50 47 | 119 13 | 690 | 7.4 | 4.0 |
| ANDERSON C | 54 02 | 128 43 | 1140 | 7.4 | 5.0 |
| BEECH CR | 49 36 | 125 12 | 460 | 7.4 | 8.2 |
| MAIDEN CR | 49 17 | 121 24 | 1700 | 7.4 | 11.0 |
| UNNAMED CR | 50 21 | 116 51 | 1000 | 7.4 | 15.0 |
| UNNAMED CR | 53 10 | 120 02 | 1830 | 7.4 | 18.0 |
| BOBB CR | 50 51 | 122 33 | 1700 | 7.4 | 22.0 |
| TSILEUH CR | 49 46 | 121 26 | 4300 | 7.5 | 5.0 |
| AYTON CR | 54 11 | 129 43 | 1000 | 7.5 | 6.0 |
| PACKSADDLE | 52 48 | 119 08 | 1400 | 7.5 | 7.5 |
| UNNAMED CR | 50 21 | 126 07 | 1000 | 7.5 | 19.0 |
| UNNAMED CR | 49 59 | 116 03 | 1600 | 7.5 | 25.0 |
| PALMERSTON | 50 27 | 126 16 | 1100 | 7.5 | 28.0 |
| UNNAMED CR | 49 29 | 126 14 | 980 | 7.5 | 32.0 |
| UNNAMED CR | 50 10 | 126 37 | 1300 | 7.6 | 7.0 |
| UNNAMED CR | 50 06 | 116 46 | 730 | 7.6 | 8.0 |
| BOLTON CR | 54 13 | 128 26 | 2100 | 7.6 | 18.0 |
| TROUT CR | 54 51 | 127 19 | 570 | 7.7 | 0.0 |
| KOKISH R | 50 29 | 126 50 | 3700 | 7.7 | 0.7 |
| UNNAMED CR | 50 07 | 116 44 | 770 | 7.7 | 13.0 |
| SHAMES R | 54 25 | 128 54 | 1880 | 7.7 | 15.0 |
| HOPE CR | 50 28 | 117 11 | 1300 | 7.7 | 24.0 |
| PRETTY GIR | 49 30 | 126 14 | 980 | 7.7 | 30.0 |
| ADRIAN CR | 49 48 | 125 27 | 650 | 7.8 | 0.0 |
| UNNAMED CR | 54 10 | 129 56 | 490 | 7.8 | 0.5 |
| BONANZA R | 50 20 | 126 44 | 1900 | 7.8 | 0.8 |
| CLUXEWE R | 50 29 | 127 09 | 800 | 7.8 | 11.0 |
| TEXAS CR | 50 31 | 121 50 | 1600 | 7.8 | 23.0 |
| BANCROFT C | 49 34 | 125 52 | 1500 | 7.8 | 26.0 |
| SEPTET CR | 50 48 | 116 41 | 1500 | 7.8 | 34.0 |
| GRIZZLY CR | 51 19 | 117 25 | 6500 | 7.8 | 50.0 |
| SWAH CR | 50 01 | 126 20 | 620 | 7.9 | 1.9 |
| DENNIS CR | 50 02 | 117 22 | 930 | 7.9 | 2.0 |
| WOODBURY C | 49 48 | 116 57 | 4190 | 7.9 | 6.0 |
| MEMEKAY R | 50 10 | 125 47 | 1400 | 7.9 | 7.5 |
| FOLEY CR | 49 08 | 121 33 | 1500 | 7.9 | 14.0 |
| SALLOOMT C | 52 27 | 126 32 | 1910 | 7.9 | N/A |
| CORN CR | 49 04 | 116 40 | 990 | 8.0 | 4.0 |
| JOHN CR | 50 16 | 117 01 | 800 | 8.0 | 4.5 |
| SMYTH CR | 50 32 | 118 43 | 1200 | 8.0 | 15.0 |
| ATLUCK CR | 50 18 | 126 56 | 1900 | 8.0 | 16.0 |
| KINMAN CR | 50 21 | 126 55 | 980 | 8.0 | 21.0 |
| TENDERFOOT | 50 28 | 117 13 | 2600 | 8.0 | 28.0 |
| TLUPANA R | 49 46 | 126 20 | 1900 | 8.1 | 2.0 |
| ASHER CR | 50 36 | 117 29 | 3600 | 8.1 | 54.0 |
| MILL CR | 55 06 | 128 07 | 1490 | 8.2 | 3.0 |
| MEADOW CR | 50 18 | 117 03 | 800 | 8.2 | 4.0 |
| SWIFT CR # | 52 52 | 119 13 | 2100 | 8.2 | 5.0 |
| UNNAMED CR | 54 05 | 128 20 | 1700 | 8.2 | 22.0 |
| DRINKWATER | 49 26 | 125 30 | 1100 | 8.2 | 23.0 |

```
KOWHOKAM C   50 02   121 31   1030   8.3    3.0
UNNAMED CR   50 08   126 37    960   8.3   11.0
UNNAMED CR   54 06   129 55   1250   8.3   12.0
HELLROARER   49 35   118 45   2000   8.3   25.0
BRENNER CR   50 13   117 30   3000   8.3   26.0
BEHRMAN CR   50 30   116 52   1230   8.3   30.0
McDOUGAL C   50 58   117 37   3600   8.3   80.0
WILSON CR    55 03   128 17    950   8.4    5.0
SWANEE CR    49 15   121 23    770   8.4   17.0
KSHADIN CR   55 27   129 03   1980   8.5    6.0
CANTELON /   49 13   121 23   2200   8.5   22.0
FLEET R      48 35   124 03   1800   8.5   24.0
BEDWELL R    49 27   125 36   1100   8.5   32.0
TOWN CR      50 46   117 45   1450   8.5   44.0
LIGNITE CR   53 55   132 37   2060   8.5    N/A
CAUSQUA CR   55 02   127 16    680   8.6    4.5
LEXINGTON    50 50   117 37   1780   8.6   58.0
PERRY R      49 54   126 37   1140   8.7    3.0
COLDWATER    54 20   128 40   1840   8.7    7.5
SONGHEES C   50 47   127 35    990   8.7    8.0
ERLANDSEN    54 36   128 44   1750   8.7    9.0
MARGARET C   49 26   125 27   1000   8.8   23.0
SHEPHERD C   49 38   125 31   1200   8.8   39.0
TAHSISH R    50 13   127 03   1300   8.8   45.0
CHRISTENSO   52 28   126 41   1830   8.8    N/A
KAUWINCH R   50 14   127 16   1000   8.9   24.0
UPANA CR     49 48   126 05   1300   9.0    0.1
DASQUE CR    54 23   128 55   1600   9.0   16.0
ALLAN CR     52 32   119 07   2300   9.1   12.0
ADOLPH CR    52 31   119 23   4300   9.1   29.0
UNNAMED CR   50 29   126 24   1380   9.1   33.0
STIKELAN C   51 27   124 22   2100   9.1    N/A
BIG TREE C   50 15   125 45   1250   9.3    1.5
UNNAMED CR   55 03   128 07   1140   9.3    3.3
LAIDLAW CR   50 52   117 14   2370   9.3   73.0
MACKIN CR    52 22   122 23    860   9.4    2.0
UNNAMED CR   54 19   128 24    790   9.4   10.0
PTARMIGAN    52 35   118 50   4100   9.4   40.0
UNNAMED CR   50 05   126 28    980   9.5    1.2
KEARY CR     50 49   122 25   1700   9.5   12.0
TRENT R      49 35   124 59    700   9.6    4.0
MARION CR    54 22   130 03    870   9.6   20.0
UNNAMED CR   49 57   126 51    380   9.6    N/A
NOR/MID ME   50 11   125 47   1400   9.7    5.5
FITZSTUBBS   50 09   117 22   4900   9.7   13.0
UNNAMED CR   50 20   116 51    620   9.7   14.0
UNNAMED CR   54 22   128 54   1900   9.7   15.0
DAVE HENRY   52 46   119 04   1400   9.7   15.0
DUCK CR      54 20   126 37   1300   9.8    2.3
TALA HAAT    54 46   130 04    660   9.8    3.0
HUMPHRYS C   54 11   128 30   1230   9.8   13.0
ZENITH CR    49 52   123 16    980   9.8   15.0
POPLAR CR    50 26   117 08   3600   9.8   17.0
BRODRICK C   49 50   126 53   1100   9.8   24.0
PAYNE CR     50 37   117 51   1100   9.8   45.0
NAKA CR      50 28   126 25   1400   9.9   31.0

A>
```

## ECONOMIC COST OF POWER FOR ALL SITES COSTING LESSTHAN 10.0 CENTS PER KWH.
## (Sorted Alphabetically)

ALL SITES BELOW 100 MILLS

| NAME | LATITUDE | LONGITUDE | CAPACITY (kw) | COST/KWH (cents) | TRANSMISSION DISTANCE (km) |
|---|---|---|---|---|---|
| ADOLPH CR | 52 31 | 119 23 | 4300 | 9.1 | 29.0 |
| ADRIAN CR | 49 46 | 125 27 | 650 | 7.8 | 0.0 |
| AIRPLANE C | 49 08 | 121 37 | 2000 | 3.2 | 7.0 |
| ALICE CR | 54 40 | 128 47 | 1250 | 7.0 | 1.8 |
| ALLAN CR | 52 32 | 119 07 | 2800 | 9.1 | 12.0 |
| AMERICAN C | 56 08 | 129 54 | 3340 | 7.1 | 25.0 |
| ANDERSON C | 49 11 | 121 43 | 1300 | 4.7 | 5.0 |
| ANDERSON C | 54 02 | 128 43 | 1140 | 7.4 | 5.0 |
| ARDEN CR | 54 19 | 129 41 | 2900 | 3.4 | N/A |
| ASHER CR | 50 36 | 117 29 | 3600 | 8.1 | 54.0 |
| ASHLU CR | 49 55 | 123 20 | 20500 | 2.3 | 5.0 |
| ATLUCK CR | 50 18 | 126 56 | 1900 | 8.0 | 16.0 |
| ATNARKO R | 52 10 | 125 42 | 20000 | 5.3 | N/A |
| AYTON CR | 54 11 | 129 43 | 1000 | 7.5 | 6.0 |
| BANCROFT C | 49 34 | 125 52 | 1500 | 7.8 | 26.0 |
| BARNEY GUL | 55 57 | 129 58 | 1590 | 5.1 | N/A |
| BEAR CR | 49 28 | 121 46 | 4100 | 3.8 | 20.0 |
| BEATRICE C | 49 50 | 117 28 | 4900 | 3.6 | 7.0 |
| BEATTON CR | 50 44 | 117 44 | 3000 | 6.7 | 46.0 |
| BEDWELL R | 49 27 | 125 36 | 1100 | 8.5 | 32.0 |
| BEECH CR | 49 36 | 125 12 | 460 | 7.4 | 8.2 |
| BEHRMAN CR | 50 30 | 116 52 | 1230 | 8.3 | 30.0 |
| BERNARD CR | 49 52 | 116 51 | 2200 | 5.9 | 20.0 |
| BIG SILVER | 49 42 | 121 51 | 9500 | 4.7 | 58.0 |
| BIG TREE C | 50 15 | 125 45 | 1250 | 9.3 | 1.5 |
| BIRKENHEAD | 50 27 | 122 41 | 6700 | 2.8 | 2.0 |
| BIRKENHEAD | 50 20 | 122 43 | 5100 | 2.8 | 1.0 |
| BLURTON CR | 50 41 | 119 02 | 1400 | 5.2 | 1.0 |
| BOBB CR | 50 51 | 122 33 | 1700 | 7.4 | 22.0 |
| BOISE CR | 49 37 | 122 41 | 9300 | 4.5 | 50.0 |
| BOLTON CR | 54 13 | 128 26 | 2100 | 7.6 | 18.0 |
| BONANZA R | 50 20 | 126 44 | 1900 | 7.8 | 0.8 |
| BOWBYES CR | 54 09 | 128 42 | 1230 | 5.0 | 8.0 |
| BOX CANYON | 49 35 | 123 24 | 2100 | 3.5 | 2.0 |
| BOYD CR | 50 53 | 117 34 | 4000 | 7.2 | 64.0 |
| BREMNER CR | 49 40 | 122 01 | 1400 | 4.5 | 7.0 |
| BRENNER CR | 50 13 | 117 30 | 3000 | 8.3 | 26.0 |
| BRODRICK C | 49 50 | 126 53 | 1100 | 9.8 | 24.0 |
| BROWN CR | 54 02 | 129 50 | 4660 | 1.7 | N/A |
| BROWNS R # | 49 42 | 125 08 | 2300 | 4.5 | 2.0 |
| BROWNS R # | 49 41 | 125 09 | 2100 | 3.3 | 2.1 |
| BUCK CR | 54 20 | 126 37 | 1300 | 9.8 | 2.3 |
| BULLDOG CR | 52 39 | 118 59 | 3900 | 5.6 | 26.0 |
| BURMAN R | 49 36 | 125 50 | 1600 | 6.9 | 26.0 |
| BUTTERWORT | 49 48 | 125 53 | 950 | 7.3 | 6.3 |
| CACOOHTIN | 52 26 | 126 19 | 2590 | 2.8 | N/A |
| CADWALLADE | 50 46 | 122 48 | 1700 | 6.4 | 0.5 |
| CALLAGHAN | 50 04 | 123 06 | 7000 | 4.7 | 2.0 |
| CAMERON R | 49 15 | 124 40 | 2200 | 3.6 | 9.0 |
| CAMP CR | 52 39 | 119 11 | 1700 | 7.2 | 2.0 |
| CAMPBELL C | 49 57 | 116 51 | 4800 | 6.9 | 12.0 |
| CANTELON / | 49 13 | 121 23 | 2200 | 8.5 | 22.0 |
| CARIBOU CR | 49 59 | 117 50 | 5300 | 4.0 | 2.5 |
| CASCADE CR | 50 25 | 117 07 | 2500 | 6.2 | 4.5 |
| CASCADE R | 56 03 | 130 02 | 1800 | 5.0 | 17.0 |

| | | | | | |
|---|---|---|---|---|---|
| CATHERINE | 50 25 | 126 36 | 1970 | 7.1 | 19.0 |
| CAUSQUA CR | 55 02 | 127 16 | 680 | 8.6 | 4.5 |
| CAYOOSH CR | 50 39 | 121 59 | 4620 | 6.3 | 1.0 |
| CAYOOSH CR | 50 39 | 122 01 | 7000 | 4.7 | 7.0 |
| CERVUS CR | 49 51 | 125 47 | 3900 | 2.0 | 1.6 |
| CHASE CR | 50 49 | 119 41 | 700 | 6.6 | 0.0 |
| CHEEKYE R | 49 48 | 123 06 | 1400 | 7.0 | 7.0 |
| CHICKWAT C | 49 49 | 123 43 | 4800 | 3.4 | 27.0 |
| CHIMDEMASH | 54 40 | 128 22 | 3950 | 5.6 | 0.0 |
| CHIPMUNK C | 49 06 | 121 39 | 6500 | 3.4 | 3.0 |
| CHRISTENSO | 52 28 | 126 41 | 1830 | 8.8 | N/A |
| CHUA CHUA | 51 21 | 120 07 | 1500 | 6.4 | 2.0 |
| CLARY CR | 55 28 | 129 27 | 6950 | 2.8 | 3.0 |
| CLAYTON FA | 52 22 | 126 49 | 2900 | 3.7 | N/A |
| CLEMINA CR | 52 34 | 119 05 | 2700 | 5.2 | 10.0 |
| CLINT CR | 50 13 | 116 54 | 4200 | 4.2 | 1.0 |
| CLOWHOM R | 49 49 | 123 23 | 3400 | 4.5 | 19.0 |
| CLOWHOM R | 49 50 | 123 29 | 3800 | 3.9 | 27.0 |
| CLOWHOM R | 49 51 | 123 27 | 3100 | 6.0 | 25.0 |
| CLUTE CR | 50 01 | 116 53 | 3500 | 6.7 | 8.0 |
| CLUXEWE R | 50 29 | 127 09 | 800 | 7.8 | 11.0 |
| COGBURN CR | 49 33 | 121 45 | 4200 | 4.3 | 35.0 |
| COLDWATER | 54 20 | 128 40 | 1840 | 8.7 | 7.5 |
| COLONEL JO | 54 13 | 130 09 | 610 | 5.9 | N/A |
| COMOX CR | 49 32 | 125 15 | 720 | 7.0 | 18.0 |
| CONNEL CR | 50 39 | 122 25 | 4400 | 7.1 | 0.5 |
| COOKE CR | 50 37 | 118 50 | 2700 | 6.6 | 0.5 |
| CORN CR | 49 04 | 116 40 | 990 | 8.0 | 4.0 |
| CRAFT CR | 50 24 | 127 15 | 1500 | 6.4 | 18.0 |
| CRAWFORD C | 50 45 | 117 59 | 1900 | 5.0 | 21.0 |
| CRUICKSHAN | 49 36 | 125 15 | 5800 | 3.4 | 18.0 |
| CULLITON C | 49 53 | 123 09 | 6800 | 5.1 | 15.0 |
| CULTUS CR | 49 20 | 116 47 | 3400 | 6.7 | 25.0 |
| CYPRESS CR | 49 20 | 123 14 | 1000 | 4.6 | 0.0 |
| DAHL CR | 54 09 | 128 43 | 1580 | 4.4 | 10.0 |
| DASQUE CR | 54 23 | 128 55 | 1600 | 9.0 | 16.0 |
| DAVE HENRY | 52 45 | 119 05 | 2300 | 5.0 | 11.0 |
| DAVE HENRY | 52 46 | 119 04 | 1400 | 9.7 | 15.0 |
| DAVIS CR | 50 08 | 116 57 | 680 | 6.6 | 0.5 |
| DENNIS CR | 50 02 | 117 22 | 930 | 7.9 | 2.0 |
| DERRY CR | 50 46 | 118 33 | 2800 | 6.7 | 22.0 |
| DORE R #1 | 53 16 | 120 17 | 4450 | 6.4 | 13.0 |
| DORE R #2 | 53 13 | 120 17 | 3420 | 7.3 | 17.0 |
| DRINKWATER | 49 26 | 125 30 | 1100 | 8.2 | 23.0 |
| DRUMMIE CR | 50 52 | 118 05 | 1300 | 5.4 | 7.0 |
| EAST CR #2 | 50 39 | 117 01 | 5000 | 4.8 | 40.0 |
| EAST CR #1 | 50 39 | 117 02 | 2500 | 6.7 | 38.0 |
| EAST TWIN | 53 28 | 120 23 | 1720 | 6.0 | 22.0 |
| EATON CR | 49 15 | 121 23 | 1900 | 5.4 | 16.0 |
| EDDY CR | 53 14 | 120 07 | 1070 | 6.9 | 10.0 |
| ELAHO CR | 50 07 | 123 26 | 19400 | 3.5 | 27.0 |
| ENGLISHMAN | 49 15 | 124 21 | 3700 | 7.2 | 2.3 |
| ERLANDSEN | 54 36 | 128 44 | 1750 | 8.7 | 9.0 |
| FALL CR | 50 36 | 118 53 | 1700 | 4.0 | 1.5 |
| FISH HATCH | 49 36 | 122 38 | 5200 | 4.6 | 50.0 |
| FITZSTUBBS | 50 09 | 117 22 | 4900 | 9.7 | 13.0 |
| FLEET R | 48 35 | 124 03 | 1800 | 8.5 | 24.0 |
| FOLEY CR | 49 08 | 121 33 | 1500 | 7.9 | 14.0 |
| FOSTHALL C | 50 22 | 117 57 | 3900 | 4.3 | 34.0 |
| FRIES CR | 49 45 | 123 09 | 2000 | 3.9 | 3.0 |

| | | | | | |
|---|---|---|---|---|---|
| FURRY CR | 49 35 | 123 13 | 5800 | 2.5 | 6.0 |
| GHITA CR | 52 51 | 118 39 | 5800 | 5.9 | 31.0 |
| GIFGERICH | 50 43 | 117 07 | 3300 | 6.6 | 55.0 |
| GLACIER CR | 55 59 | 129 56 | 1270 | 7.3 | N/A |
| GOAT CR | 54 43 | 128 46 | 1120 | 4.8 | 4.0 |
| GOLD CR | 49 21 | 122 27 | 1900 | 4.7 | 16.0 |
| GOLD R | 49 52 | 126 06 | 4400 | 5.9 | 4.4 |
| GRANT BROO | 52 54 | 118 45 | 4200 | 4.9 | 21.0 |
| GRAY CR | 49 32 | 123 45 | 2490 | 4.1 | 8.0 |
| GRIZZLY CR | 51 19 | 117 25 | 6500 | 7.8 | 50.0 |
| GWILLIM CR | 49 45 | 117 28 | 4200 | 2.8 | 1.0 |
| HADOW CR | 50 40 | 117 48 | 4200 | 3.6 | 41.0 |
| HALFWAY HO | 50 29 | 117 51 | 5700 | 6.7 | 22.0 |
| HANDY CR | 49 00 | 124 56 | 2700 | 3.5 | 29.0 |
| HARDSCRABB | 54 42 | 128 20 | 1270 | 6.2 | 8.0 |
| HEADQUARTE | 49 42 | 125 07 | 540 | 6.1 | 1.4 |
| HELLROARER | 49 35 | 118 45 | 2000 | 8.3 | 25.0 |
| HIGH CR | 49 55 | 123 52 | 3300 | 3.5 | 21.0 |
| HIGH FALLS | 49 56 | 123 18 | 7500 | 2.4 | 1.0 |
| HILLS CR | 50 43 | 119 04 | 1200 | 6.0 | 3.0 |
| HOPE CR | 50 28 | 117 11 | 1300 | 7.7 | 24.0 |
| HORSEY CR | 53 08 | 119 41 | 5150 | 6.1 | 14.0 |
| HOTNARKO R | 52 23 | 125 45 | 8500 | 5.1 | N/A |
| HUMMING BI | 50 46 | 119 00 | 550 | 7.3 | 1.0 |
| HUMPHRYS C | 54 11 | 128 30 | 1230 | 9.8 | 13.0 |
| HUNLEN CR | 52 17 | 125 45 | 10500 | 2.3 | N/A |
| JANET CR | 52 23 | 125 52 | 4100 | 4.0 | N/A |
| JOFFRE CR | 49 18 | 122 35 | 5200 | 2.3 | 10.0 |
| JOHN CR | 50 16 | 117 01 | 800 | 8.0 | 4.5 |
| KAIN CR | 50 51 | 116 35 | 1700 | 5.1 | 16.0 |
| KAIPIT CR | 50 15 | 126 48 | 4200 | 3.4 | 6.0 |
| KAUWINCH R | 50 14 | 127 16 | 1000 | 8.9 | 24.0 |
| KEARY CR | 50 49 | 122 25 | 1700 | 9.5 | 12.0 |
| KELLIE CR | 50 55 | 117 34 | 3100 | 6.7 | 65.0 |
| KELSKIIST | 55 21 | 129 42 | 4500 | 4.0 | 28.0 |
| KHTADA CR | 54 11 | 129 36 | 6690 | 2.7 | 0.5 |
| KINMAN CR | 50 21 | 126 55 | 980 | 8.0 | 21.0 |
| KLEANZA CR | 54 36 | 128 22 | 6060 | 3.2 | 2.0 |
| KOKISH R | 50 27 | 126 47 | 4700 | 4.0 | 3.0 |
| KOKISH R | 50 31 | 126 52 | 12000 | 2.7 | 0.5 |
| KOKISH R | 50 28 | 126 48 | 2390 | 6.8 | 2.8 |
| KOKISH R | 50 29 | 126 50 | 3700 | 7.7 | 0.7 |
| KOOKIPI CR | 49 59 | 121 38 | 11600 | 4.9 | 12.0 |
| KSHADIN CR | 55 27 | 129 03 | 1980 | 8.5 | 6.0 |
| KUSHANAX C | 50 16 | 117 46 | 6300 | 3.9 | 0.0 |
| KWINATAHL | 55 25 | 129 08 | 6000 | 3.7 | 1.0 |
| KWOIEK CR | 50 07 | 121 35 | 18600 | 4.1 | 7.0 |
| LADYBIRD C | 49 25 | 117 40 | 1780 | 4.5 | 2.5 |
| LAFORGUE C | 49 14 | 121 09 | 1300 | 5.9 | 27.0 |
| LAIDLAW CR | 50 52 | 117 14 | 2370 | 9.3 | 73.0 |
| LAKE LOVEL | 49 48 | 123 13 | 5900 | 4.7 | 9.0 |
| LASCA CR | 49 36 | 117 09 | 3200 | 4.9 | 1.0 |
| LATEWHOS C | 50 27 | 118 43 | 2100 | 6.3 | 8.0 |
| LEGERWOOD | 50 58 | 118 46 | 950 | 6.4 | 1.5 |
| LEINER R | 49 56 | 126 37 | 1700 | 5.8 | 4.0 |
| LEXINGTON | 50 50 | 117 37 | 1780 | 8.6 | 58.0 |
| LIGNITE CR | 53 55 | 132 37 | 2060 | 8.5 | N/A |
| LIZZIE CR | 50 12 | 122 28 | 5700 | 3.7 | 1.0 |
| LOFTUS CR | 50 56 | 118 49 | 1350 | 4.6 | 0.5 |
| LOKI CR | 49 50 | 116 51 | 2600 | 6.8 | 14.0 |

| | | | | | |
|---|---|---|---|---|---|
| LOST LEDGE | 50 06 | 116 56 | 860 | 6.6 | 0.5 |
| LOST VALLE | 50 40 | 122 18 | 2300 | 3.4 | 6.0 |
| LYNN CR | 49 21 | 123 01 | 2100 | 7.1 | 0.0 |
| MACKIN CR | 52 22 | 122 23 | 860 | 9.4 | 2.0 |
| MACKTUSH C | 49 06 | 124 51 | 1000 | 7.2 | 10.0 |
| MAIMEN CR | 49 17 | 121 24 | 1700 | 7.4 | 11.0 |
| MAMQUAM CR | 49 43 | 123 04 | 28700 | 1.8 | 6.0 |
| MAQUILLA C | 50 05 | 126 25 | 2200 | 7.1 | 0.8 |
| MARA CR | 50 46 | 119 00 | 850 | 6.2 | 1.0 |
| MARGARET C | 49 26 | 125 27 | 1000 | 8.8 | 23.0 |
| MARION CR | 54 22 | 130 03 | 870 | 9.6 | 20.0 |
| MARMOT R | 55 53 | 130 00 | 2460 | 5.2 | N/A |
| MASELPANIK | 49 07 | 121 15 | 5100 | 4.6 | 37.0 |
| MAWBY CR | 49 53 | 123 18 | 2700 | 3.2 | 2.0 |
| MAYNARD L | 50 24 | 127 14 | 4190 | 3.0 | 18.0 |
| MEADOW CR | 50 18 | 117 03 | 800 | 8.2 | 4.0 |
| MEMEKAY R | 50 10 | 125 47 | 1400 | 7.9 | 7.5 |
| MESS CR | 57 53 | 131 12 | 10300 | 7.1 | N/A |
| MILL CR | 52 24 | 126 34 | 4800 | 2.8 | N/A |
| MILL CR | 55 06 | 128 07 | 1490 | 8.2 | 3.0 |
| MOAKWA CR | 50 07 | 126 02 | 2000 | 6.9 | 22.0 |
| MOLYBDDDEN | 54 34 | 128 45 | 1090 | 5.5 | 8.5 |
| MONMOUTH C | 49 43 | 123 11 | 2040 | 3.4 | 3.0 |
| MONTAGUE C | 50 20 | 126 12 | 2400 | 5.9 | 22.0 |
| MOOSE R | 52 55 | 118 48 | 6800 | 3.2 | 15.0 |
| MOSHER CR | 52 25 | 125 58 | 3450 | 4.9 | N/A |
| MOWHOKAM C | 50 02 | 121 31 | 1000 | 8.3 | 3.0 |
| MUCHALAT R | 49 53 | 126 19 | 880 | 7.0 | 12.0 |
| MULVEHILL | 50 51 | 118 07 | 2000 | 3.2 | 0.5 |
| McDONALD C | 50 34 | 116 25 | 3100 | 4.0 | 28.0 |
| McDONALD C | 54 07 | 129 54 | 2600 | 3.3 | 0.5 |
| McDOUGAL C | 50 58 | 117 37 | 3600 | 8.3 | 80.0 |
| McGILLIVAR | 50 37 | 122 26 | 2900 | 3.3 | 1.0 |
| McKAY CR | 54 13 | 128 25 | 5370 | 5.6 | 18.0 |
| McKELVIE C | 49 56 | 126 39 | 1580 | 4.1 | 4.0 |
| McLENNON R | 52 51 | 119 21 | 2500 | 4.5 | 6.0 |
| McNAIR CR | 49 31 | 123 30 | 2800 | 4.4 | 1.0 |
| McNULTY CR | 49 25 | 120 05 | 2200 | 6.7 | 10.0 |
| NAREELAH C | 54 08 | 128 32 | 920 | 6.6 | 6.0 |
| NAKA CR | 50 28 | 126 25 | 1400 | 9.9 | 31.0 |
| NEMO CR | 49 55 | 117 25 | 7100 | 6.3 | 3.0 |
| NEWCASTLE | 50 22 | 126 07 | 1300 | 6.6 | 15.0 |
| NEXT CR | 49 18 | 116 45 | 3000 | 4.8 | 22.0 |
| NICOAMEN C | 50 16 | 121 24 | 2200 | 3.4 | 10.0 |
| NOEICK R | 52 05 | 126 34 | 12200 | 4.6 | N/A |
| NOEL CR | 50 46 | 122 48 | 1160 | 6.8 | 2.0 |
| NOOKLIKONN | 52 22 | 126 34 | 4480 | 3.5 | N/A |
| NOOMST CR | 52 23 | 126 15 | 4070 | 5.0 | N/A |
| NOOMST CR | 52 26 | 126 13 | 1480 | 4.9 | N/A |
| NOOSGULCH | 52 26 | 126 23 | 1800 | 7.2 | N/A |
| NOR/MID MF | 50 11 | 125 47 | 1400 | 9.7 | 5.5 |
| NORA CR | 50 08 | 126 02 | 1200 | 6.9 | 22.0 |
| NORDSCHOW | 52 18 | 126 03 | 3790 | 4.2 | N/A |
| OWL CR | 50 22 | 122 44 | 2400 | 3.4 | 1.0 |
| PACKSADDLE | 52 48 | 119 08 | 1400 | 7.5 | 7.5 |
| PALMERSTON | 50 27 | 126 16 | 1100 | 7.5 | 28.0 |
| PAYNE CR | 50 37 | 117 51 | 1100 | 9.8 | 45.0 |
| PERKETTS C | 49 53 | 123 52 | 4500 | 2.6 | 15.0 |
| PERRY R | 49 54 | 126 37 | 1140 | 8.7 | 3.0 |
| PHILLIPS C | 49 40 | 125 34 | 2800 | 5.9 | 27.0 |

| | | | | | |
|---|---|---|---|---|---|
| PIGGOTT CR | 49 49 | 125 22 | 1900 | 3.6 | 14.0 |
| POOL CR | 50 47 | 117 38 | 6200 | 6.3 | 51.0 |
| POPLAR CR | 50 26 | 117 08 | 3600 | 9.8 | 17.0 |
| POST CR | 49 05 | 121 28 | 1020 | 5.8 | 17.0 |
| POWDER CR | 49 53 | 116 51 | 3600 | 6.8 | 23.0 |
| PRETTY GIR | 49 30 | 126 14 | 980 | 7.7 | 30.0 |
| PTARMIGAN | 52 35 | 118 50 | 4100 | 9.4 | 40.0 |
| RAINY R | 49 32 | 123 30 | 3070 | 4.8 | 3.0 |
| RAPID CR | 50 27 | 117 10 | 2500 | 7.0 | 21.0 |
| RED TUSK C | 49 47 | 123 25 | 3300 | 4.6 | 13.0 |
| REINECKER | 50 47 | 119 13 | 690 | 7.4 | 4.0 |
| ROARING CR | 49 27 | 122 13 | 2000 | 4.8 | 25.0 |
| ROBSON R | 53 03 | 119 13 | 2690 | 6.8 | 2.5 |
| ROGERS CR | 49 39 | 122 27 | 9100 | 2.8 | 1.0 |
| ROSEWALL C | 49 27 | 124 48 | 2100 | 3.2 | 1.0 |
| RUBBLE CR | 49 57 | 123 07 | 14700 | 2.9 | 4.0 |
| SACHS CR | 53 12 | 131 58 | 780 | 6.9 | N/A |
| SALLOOMT C | 52 27 | 126 32 | 1910 | 7.9 | N/A |
| SALMON R | 50 05 | 126 41 | 2700 | 4.8 | 19.0 |
| SANCA CR | 49 23 | 116 43 | 2000 | 4.7 | 1.0 |
| SAUNDERS C | 49 48 | 126 01 | 2000 | 5.3 | 2.0 |
| SCHROEDER | 50 02 | 116 55 | 1400 | 6.7 | 0.5 |
| SCUZZZY CR | 49 49 | 121 28 | 3900 | 6.1 | 3.0 |
| SEASKINNIS | 55 16 | 128 59 | 2330 | 6.4 | 2.0 |
| SECHELT CR | 49 40 | 123 33 | 6600 | 2.6 | 0.5 |
| SEDAN CR | 55 05 | 128 12 | 2030 | 5.9 | 8.0 |
| SEPTET CR | 50 48 | 116 41 | 1500 | 7.8 | 34.0 |
| SHAMES R | 54 25 | 128 54 | 1880 | 7.7 | 15.0 |
| SHANNON CR | 50 05 | 117 29 | 1900 | 5.6 | 2.0 |
| SHANNON CR | 54 40 | 127 30 | 1300 | 6.9 | 17.0 |
| SHAW CR | 49 15 | 116 43 | 1900 | 4.1 | 17.0 |
| SHEPHERD C | 49 38 | 125 31 | 1200 | 8.8 | 39.0 |
| SICAMOUS C | 50 48 | 118 58 | 2300 | 4.1 | 0.0 |
| SIWASH CR | 49 34 | 121 24 | 4200 | 3.9 | 12.0 |
| SMALL CR | 53 04 | 119 35 | 4000 | 7.3 | 7.0 |
| SMITELY R | 52 05 | 126 36 | 4100 | 6.0 | N/A |
| SMITELY R | 52 07 | 126 39 | 6300 | 3.8 | N/A |
| SMYTH CR | 50 32 | 118 43 | 1200 | 8.0 | 15.0 |
| SNOOTLI CR | 52 23 | 126 36 | 2420 | 3.7 | N/A |
| SONGHEES C | 50 47 | 127 35 | 990 | 8.7 | 8.0 |
| SOUTH ENGL | 49 15 | 124 17 | 3300 | 6.1 | 5.0 |
| SOUTH CRAN | 50 46 | 118 06 | 3800 | 2.9 | 6.0 |
| SOWERBY CR | 49 19 | 121 26 | 4100 | 5.1 | 7.0 |
| SPUZZUM CR | 49 39 | 121 26 | 2600 | 4.3 | 2.0 |
| SQUAMISH R | 50 10 | 123 24 | 11400 | 4.6 | 30.0 |
| STAWAMUS C | 49 42 | 123 07 | 5500 | 4.1 | 3.0 |
| STE CROIX | 54 42 | 128 19 | 1490 | 6.2 | 6.0 |
| STIKELAN C | 51 27 | 124 22 | 2100 | 9.1 | N/A |
| SWAH CR | 50 01 | 126 20 | 620 | 7.9 | 1.9 |
| SWANEE CR | 49 15 | 121 23 | 770 | 8.4 | 17.0 |
| SWIFT CR # | 52 52 | 119 13 | 2100 | 8.2 | 5.0 |
| SWIFTCURRE | 53 01 | 119 17 | 2550 | 5.8 | 0.5 |
| TAHSISH R | 50 13 | 127 03 | 1300 | 8.8 | 45.0 |
| TALA HAAT | 54 46 | 130 04 | 660 | 9.8 | 5.0 |
| TAM O'SHAN | 49 48 | 116 51 | 3400 | 6.7 | 3.0 |
| TANTALUS C | 49 51 | 123 15 | 4900 | 4.4 | 2.0 |
| TAQUAT CR | 49 45 | 123 25 | 6700 | 2.7 | 11.0 |
| TASTSQUAN | 52 22 | 126 45 | 1200 | 3.2 | N/A |
| TEMPLETON | 50 48 | 116 29 | 1800 | 6.7 | 21.0 |
| TENDERFOOT | 50 28 | 117 13 | 2600 | 8.0 | 28.0 |

| | | | | | |
|---|---|---|---|---|---|
| TEXAS CR | 50 34 | 121 49 | 2700 | 4.4 | 13.0 |
| TEXAS CR | 50 31 | 121 50 | 1600 | 7.8 | 23.0 |
| THELWOOD C | 49 33 | 125 34 | 2100 | 6.4 | 41.0 |
| THOMAS LAK | 49 36 | 122 25 | 4100 | 4.3 | 50.0 |
| THORNHILL | 49 40 | 123 36 | 3970 | 2.5 | 0.0 |
| THORSEN CR | 52 21 | 126 42 | 3500 | 5.0 | N/A |
| TIPELLA CR | 49 45 | 122 10 | 3200 | 2.6 | 0.0 |
| TLATLOS CR | 50 23 | 126 14 | 2700 | 7.0 | 26.0 |
| TLODIS CR | 49 52 | 125 45 | 1070 | 6.5 | 1.0 |
| TLUPANA R | 49 46 | 126 20 | 1900 | 8.1 | 2.0 |
| TOMMY CR | 50 50 | 122 31 | 2500 | 5.2 | 20.0 |
| TOWN CR | 50 46 | 117 45 | 1450 | 8.5 | 44.0 |
| TRENT R | 49 35 | 124 59 | 700 | 9.6 | 4.0 |
| TRETHEWAY | 49 42 | 122 05 | 1600 | 5.1 | 0.0 |
| TROUT CR | 54 51 | 127 19 | 570 | 7.7 | 0.0 |
| TRUAX CR | 50 53 | 122 38 | 1400 | 5.3 | 18.0 |
| TSABLE R | 49 31 | 124 54 | 2400 | 3.6 | 4.0 |
| TSEAPSEAHO | 52 26 | 126 24 | 2470 | 3.8 | N/A |
| TSILEUH CR | 49 46 | 121 26 | 4300 | 7.5 | 3.0 |
| TSINI-TSIN | 52 22 | 126 06 | 1790 | 4.8 | N/A |
| TSUIUS CR | 50 37 | 118 40 | 5300 | 4.6 | 7.0 |
| TWENTYONE | 50 07 | 122 59 | 2900 | 2.7 | 1.0 |
| TWIN ONE C | 50 15 | 122 30 | 6900 | 6.5 | 1.0 |
| TZOONIE CR | 49 47 | 123 43 | 2400 | 6.3 | 23.0 |
| UCONA R | 49 44 | 125 57 | 2300 | 3.1 | 10.0 |
| UNNAMED CR | 49 09 | 121 15 | 1570 | 6.7 | 30.0 |
| UNNAMED CR | 49 45 | 123 27 | 3500 | 2.9 | 11.0 |
| UNNAMED CR | 50 57 | 118 24 | 2500 | 3.4 | 6.0 |
| UNNAMED CR | 49 45 | 123 31 | 4800 | 2.0 | 6.0 |
| UNNAMED CR | 52 55 | 118 53 | 3450 | 2.8 | 11.0 |
| UNNAMED CR | 49 40 | 121 51 | 2500 | 6.7 | 55.0 |
| UNNAMED CR | 49 43 | 123 45 | 3200 | 3.5 | 17.0 |
| UNNAMED CR | 50 01 | 123 21 | 3500 | 2.9 | 15.0 |
| UNNAMED CR | 49 47 | 123 34 | 4600 | 3.5 | 17.0 |
| UNNAMED CR | 52 56 | 118 53 | 6800 | 3.1 | 11.0 |
| UNNAMED CR | 50 30 | 126 54 | 620 | 6.7 | 1.6 |
| UNNAMED CR | 49 29 | 121 25 | 1300 | 6.5 | 3.0 |
| UNNAMED CR | 52 10 | 126 50 | 8400 | 4.8 | N/A |
| UNNAMED CR | 50 58 | 118 36 | 1100 | 5.0 | 7.0 |
| UNNAMED CR | 49 41 | 123 35 | 1100 | 6.7 | 8.0 |
| UNNAMED CR | 54 05 | 129 56 | 820 | 5.9 | 12.0 |
| UNNAMED CR | 54 11 | 129 45 | 1300 | 5.9 | 10.0 |
| UNNAMED CR | 49 48 | 123 24 | 4280 | 5.4 | 13.0 |
| UNNAMED CR | 49 41 | 123 16 | 1770 | 4.6 | 2.5 |
| UNNAMED CR | 49 57 | 121 50 | 5800 | 5.3 | 28.0 |
| UNNAMED CR | 49 46 | 125 41 | 3500 | 4.1 | 20.0 |
| UNNAMED CR | 53 08 | 120 01 | 2240 | 6.9 | 23.0 |
| UNNAMED CR | 50 10 | 126 20 | 1300 | 5.6 | 13.0 |
| UNNAMED CR | 52 21 | 126 40 | 2800 | 5.4 | N/A |
| UNNAMED CR | 52 01 | 126 32 | 6280 | 4.3 | N/A |
| UNNAMED CR | 49 49 | 123 23 | 2200 | 4.3 | 17.0 |
| UNNAMED CR | 50 29 | 122 22 | 1500 | 5.9 | 8.0 |
| UNNAMED CR | 54 27 | 130 04 | 1180 | 5.8 | 30.0 |
| UNNAMED CR | 54 20 | 129 46 | 2000 | 4.3 | 16.0 |
| UNNAMED CR | 52 54 | 118 46 | 2700 | 4.0 | 24.0 |
| UNNAMED CR | 49 44 | 123 32 | 1300 | 3.8 | 5.0 |
| UNNAMED CR | 49 46 | 123 26 | 2090 | 3.8 | 14.0 |
| UNNAMED CR | 52 10 | 126 50 | 3500 | 3.8 | N/A |
| UNNAMED CR | 49 50 | 121 31 | 4300 | 5.2 | 9.0 |
| UNNAMED CR | 50 07 | 126 36 | 1400 | 6.4 | 9.0 |

```
UNNAMED CR    50 55   118 07    1300   4.7    N/A
UNNAMED CR    49 45   123 43    2340   3.6   18.0
UNNAMED CR    54 23   128 53    1800   6.1   15.0
UNNAMED CR    50 29   127 21     770   6.9   10.0
UNNAMED CR    50 59   116 45    2000   5.7   28.0
UNNAMED CR    49 55   123 48    3650   6.1   25.0
UNNAMED CR    49 40   123 35    1140   6.2    0.0
UNNAMED CR    49 09   121 20    2000   6.8   30.0
UNNAMED CR    50 20   116 51     620   9.7   14.0
UNNAMED CR    54 22   128 54    1900   9.7   15.0
UNNAMED CR    49 57   126 51     380   9.6    N/A
UNNAMED CR    50 10   126 37    1300   7.6    7.0
UNNAMED CR    49 29   126 14     980   7.5   32.0
UNNAMED CR    49 59   116 03    1600   7.5   25.0
UNNAMED CR    49 15   121 15    1200   7.3   25.0
UNNAMED CR    49 12   121 20    1300   7.1   24.0
UNNAMED CR    50 10   126 18     940   7.1   14.0
UNNAMED CR    50 21   126 07    1000   7.5   19.0
UNNAMED CR    53 10   120 02    1830   7.4   18.0
UNNAMED CR    50 21   116 51    1000   7.4   15.0
UNNAMED CR    55 03   128 07    1140   9.3    3.3
UNNAMED CR    54 06   129 55    1250   8.3   12.0
UNNAMED CR    50 08   126 37     960   8.3   11.0
UNNAMED CR    50 29   126 24    1380   9.1   33.0
UNNAMED CR    54 05   128 20    1700   8.2   22.0
UNNAMED CR    54 10   129 56     490   7.8    0.5
UNNAMED CR    50 06   116 46     730   7.6    8.0
UNNAMED CR    50 05   126 28     980   9.5    1.2
UNNAMED CR    54 19   128 24     790   9.4   10.0
UNNAMED CR    50 07   116 44     770   7.7   13.0
UPANA CR      49 48   126 05    1300   9.0    0.1
URF CR        50 16   122 35   11800   3.3   10.0
VANCOUVER     49 56   123 48    3500   6.1   25.0
VICTOR CR     50 57   118 24    1100   4.7    6.0
WADY CR       50 24   127 17    1500   4.9   16.0
WALT LAKE     49 53   124 08     750   6.4   16.0
WARREN CR     50 58   116 42    5500   6.3   24.0
WEDGE CR      50 10   122 54    5500   2.6    2.0
WEE SANDY     50 00   117 25    2300   4.0   10.0
WHITE R       50 18   125 56    6300   4.0    2.0
WHITE CR      54 24   128 41    1390   6.8    8.0
WHITECAP C    50 43   122 18    1050   5.6    1.0
WILFRED CR    49 28   124 51     540   6.8    3.5
WILLIAMS C    54 24   128 25    3290   5.1    6.0
WILSON CR     49 35   116 52    2500   6.1   12.0
WILSON CR     50 08   117 20    3900   4.3   11.0
WILSON CR     55 03   128 17     950   8.4    5.0
WOODBURY C    49 48   116 57    4190   7.9    6.0
WRAGGE CR     50 04   117 28    1990   5.4    2.0
WRAY CR       49 20   121 18    1800   4.9   12.0
YARD CR       50 54   118 48    3290   4.9    0.0
YELLOWJACK    52 43   119 03    1400   6.6   17.0
YOUNG CR      52 25   125 53   18000   2.8    N/A
ZEBALLOS R    50 03   126 47    2400   5.2    N/A
ZEBALLOS L    50 03   126 46    3500   4.7    N/A
ZEBALLOS(L    49 59   126 45    2300   2.5    N/A
ZENITH CR     49 52   123 16     980   9.8   15.0

A>
```

# APPENDIX 2

# APPENDIX 2

## SMALL HYDRO POWER CUMULATIVE CHARACTERISTICS VS EQUIVALENT NON-INFLATED COST PER KILOWATT-HOUR

**Presented for:**

1. All Sites
2. On-Grid Sites Only

**Assumptions:**

1. Operating costs @ 1.2% of capital costs per year for plant and transmission lines, but no less than $40,000 per year for any plant.
2. 50 year time horizon.
3. All construction costs incurred one year prior to first energy production for each site.
4. Transmission losses to grid and downtime reduce power output by 10%.
5. Water taxes not included.
6. Property and school taxes not included.
7. Costs of transmission to grid are included in capital cost where appropriate.
8. Cost per kW.h includes costs of operation and maintenance.
9. Contingency factor of 30%. Assumed to include land cost, interconnection to grid where appropriate.
10. No real inflation of operating costs.
11. Average cost per kW.h includes all sites up to a given cost per kW.h.
12. No sharing of transmission line for nearby sites.
13. Project management overhead of 8% of capital costs.
14. Discount rate of 8%.

```
CAPACITIES REDUCED BY FISH PASS, DOWN TIME AND TRANSMISSION LINE LOSSES
MEAN    DISCOUNT RATE - 8 %    OPERATION AND MAINTENANCE RATE - 1.2 %                    MANAGEMENT FEE    8 %              ALL SITES (Page 1 of 2)
WATER TAXES ARE NOT INCLUDED,  TRANSMISSION COST FACTOR NOT INCLUDED

 COST C/KWH    # SITES  MEAN CAP.    ENERGY    TOTAL # SITES  INSTALLED CAPACITY  CUM. MEAN CAP.   CUM. ENERGY    AV. COST/KWH  CUM. CAP. COST
                           KW        GWH/YR                           KW               KW            GWH/YR         C/KWH       ($1,000,000)

 0.0  TO  0.1     0          0          0             0                  0               0              0           0.00            0
 0.1  TO  0.2     0          0          0             0                  0               0              0           0.00            0
 0.2  TO  0.3     0          0          0             0                  0               0              0           0.00            0
 0.3  TO  0.4     0          0          0             0                  0               0              0           0.00            0
 0.4  TO  0.5     0          0          0             0                  0               0              0           0.00            0
 0.5  TO  0.6     0          0          0             0                  0               0              0           0.00            0
 0.6  TO  0.7     0          0          0             0                  0               0              0           0.00            0
 0.7  TO  0.8     0          0          0             0                  0               0              0           0.00            0
 0.8  TO  0.9     0          0          0             0                  0               0              0           0.00            0
 0.9  TO  1.0     0          0          0             0                  0               0              0           0.00            0
 1.0  TO  1.1     0          0          0             0                  0               0              0           0.00            0
 1.1  TO  1.2     0          0          0             0                  0               0              0           0.00            0
 1.2  TO  1.3     0          0          0             0                  0               0              0           0.00            0
 1.3  TO  1.4     0          0          0             0                  0               0              0           0.00            0
 1.4  TO  1.5     0          0          0             0                  0               0              0           0.00            0
 1.5  TO  1.6     0          0          0             0                  0               0              0           0.00            0
 1.6  TO  1.7     0          0          0             0                  0               0              0           0.00            0
 1.7  TO  1.8     1      3,020         26             1               4660           3,020             26           1.75            5
 1.8  TO  1.9     1     14,723        129             2              28700          17,743            155           1.82           30
 1.9  TO  2.0     2      4,658         41             4               8700          22,400            196           1.86           39
 2.0  TO  2.1     0          0          0             4                  0          22,400            196           1.86           39
 2.1  TO  2.2     0          0          0             4                  0          22,400            196           1.86           39
 2.2  TO  2.3     0          0          0             4                  0          22,400            196           1.86           39
 2.3  TO  2.4     3     18,958        166             7              36200          41,358            362           2.07           80
 2.4  TO  2.5     2      5,678         50             9              11470          47,036            412           2.11           93
 2.5  TO  2.6     4     10,558         92            13              20200          57,593            505           2.20          118
 2.6  TO  2.7     6     20,253        177            19              35990          77,846            682           2.32          169
 2.7  TO  2.8     4     19,947        175            23              35100          97,793            857           2.41          220
 2.8  TO  2.9     9     26,923        236            32              51290         124,716          1,093           2.51          292
 2.9  TO  3.0     0          0          0            32                  0         124,716          1,093           2.51          292
 3.0  TO  3.1     2      5,511         48            34              10990         130,227          1,141           2.53          308
 3.1  TO  3.2     4      6,656         58            38              12260         136,884          1,199           2.56          327
 3.2  TO  3.3     8     16,453        144            46              32300         153,337          1,343           2.64          377
 3.3  TO  3.4     2      4,406         39            48               8300         157,742          1,382           2.66          391
 3.4  TO  3.5    13     22,802        200            61              43240         180,544          1,582           2.75          464
 3.5  TO  3.6     3     14,255        125            64              26220         194,799          1,706           2.81          511
 3.6  TO  3.7     5      7,592         67            69              15600         202,391          1,773           2.84          537
 3.7  TO  3.8     6     12,358        108            75              22610         214,750          1,881           2.89          580
 3.8  TO  3.9     7     12,866        113            82              24370         227,616          1,994           2.95          626
 3.9  TO  4.0     3      8,610         75            85              17900         236,226          2,069           2.98          658
 4.0  TO  4.1    12     29,010        254            97              55490         265,236          2,323           3.10          768
 4.1  TO  4.2     3      3,755         33           100               7680         268,991          2,356           3.12          782
 4.2  TO  4.3     5     10,205         89           105              18570         279,196          2,446           3.16          823
 4.3  TO  4.4     7     10,675         94           112              21480         289,870          2,539           3.20          866
 4.4  TO  4.5     3      4,896         43           115               9700         294,766          2,582           3.22          886
 4.5  TO  4.6     8     18,691        164           123              35530         313,457          2,746           3.30          965
 4.6  TO  4.7    10     22,238        195           133              43770         335,695          2,941           3.39         1061
 4.7  TO  4.8     9     20,651        181           142              39120         356,346          3,122           3.47         1153
 4.8  TO  4.9     8     15,029        132           150              31590         371,375          3,253           3.53         1221
 4.9  TO  5.0     6      6,642         58           156              13920         378,017          3,311           3.55         1252
 5.0  TO  5.1     9     17,876        157           165              33870         395,894          3,468           3.62         1336
 5.1  TO  5.2     7      7,712         68           172              15480         403,605          3,536           3.65         1373
```

(Page 2 of 2)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.2 | TO | 5.3 | 4 | 6,474 | 56 | 176 | 14560 | 416,031 | 3,552 | 3.67 | [illegible] |
| 5.3 | TO | 5.4 | 3 | 17,625 | 111 | 179 | 23400 | [illegible] | 3,702 | 3.72 | [illegible] |
| 5.4 | TO | 5.5 | 6 | 6,755 | 59 | 185 | 13360 | 428,811 | 3,762 | 3.75 | 1501 |
| 5.5 | TO | 5.6 | 3 | 2,644 | 18 | 188 | 4350 | 431,455 | 3,780 | 3.76 | 1511 |
| 5.6 | TO | 5.7 | 3 | 6,788 | 59 | 191 | 13220 | 438,243 | 3,839 | 3.79 | 1547 |
| 5.7 | TO | 5.8 | 4 | 3,436 | 30 | 195 | 6450 | 441,679 | 3,869 | 3.80 | 1565 |
| 5.8 | TO | 5.9 | 7 | 7,364 | 65 | 202 | 14630 | 449,043 | 3,934 | 3.84 | 1605 |
| 5.9 | TO | 6.0 | 5 | 8,526 | 75 | 207 | 14630 | 457,569 | 4,008 | 3.88 | 1653 |
| 6.0 | TO | 6.1 | 5 | 6,251 | 55 | 212 | 13570 | 463,820 | 4,063 | 3.90 | 1688 |
| 6.1 | TO | 6.2 | 7 | 9,855 | 86 | 221 | 20050 | 473,674 | 4,149 | 3.95 | 1744 |
| 6.2 | TO | 6.3 | 4 | 7,695 | 67 | 225 | 17290 | 481,369 | 4,217 | 3.99 | 1789 |
| 6.3 | TO | 6.4 | 11 | 13,967 | 122 | 236 | 28850 | 495,336 | 4,339 | 4.05 | 1872 |
| 6.4 | TO | 6.5 | 4 | 5,414 | 47 | 240 | 10650 | 500,750 | 4,387 | 4.08 | 1904 |
| 6.5 | TO | 6.6 | 6 | 4,228 | 37 | 246 | 7310 | 504,979 | 4,424 | 4.10 | 1930 |
| 6.6 | TO | 6.7 | 11 | 10,416 | 91 | 257 | 22120 | 515,395 | 4,515 | 4.15 | 1994 |
| 6.7 | TO | 6.8 | 12 | 14,361 | 126 | 269 | 30840 | 529,756 | 4,641 | 4.22 | 2085 |
| 6.8 | TO | 6.9 | 8 | 6,282 | 55 | 277 | 11910 | 536,038 | 4,696 | 4.25 | 2125 |
| 6.9 | TO | 7.0 | 7 | 6,667 | 58 | 284 | 13940 | 542,705 | 4,754 | 4.29 | 2167 |
| 7.0 | TO | 7.1 | 7 | 6,514 | 57 | 291 | 11390 | 549,220 | 4,811 | 4.32 | 2210 |
| 7.1 | TO | 7.2 | 7 | 12,443 | 109 | 298 | 26940 | 561,662 | 4,920 | 4.38 | 2293 |
| 7.2 | TO | 7.3 | 7 | 4,652 | 41 | 305 | 9370 | 566,314 | 4,961 | 4.41 | 2325 |
| 7.3 | TO | 7.4 | 3 | 3,955 | 35 | 308 | 8560 | 570,269 | 4,996 | 4.43 | 2352 |
| 7.4 | TO | 7.5 | 10 | 7,125 | 62 | 318 | 15260 | 577,393 | 5,058 | 4.46 | 2400 |
| 7.5 | TO | 7.6 | 4 | 3,028 | 27 | 322 | 5600 | 580,421 | 5,084 | 4.48 | 2422 |
| 7.6 | TO | 7.7 | 6 | 5,288 | 46 | 328 | 9360 | 585,709 | 5,131 | 4.51 | 2459 |
| 7.7 | TO | 7.8 | 7 | 6,951 | 61 | 335 | 13760 | 592,660 | 5,192 | 4.55 | 2509 |
| 7.8 | TO | 7.9 | 5 | 3,530 | 31 | 340 | 6360 | 596,190 | 5,223 | 4.57 | 2535 |
| 7.9 | TO | 8.0 | 6 | 4,599 | 40 | 346 | 9430 | 600,789 | 5,263 | 4.59 | 2569 |
| 8.0 | TO | 8.1 | 4 | 3,149 | 28 | 350 | 6280 | 603,939 | 5,291 | 4.61 | 2592 |
| 8.1 | TO | 8.2 | 3 | 3,633 | 32 | 353 | 6990 | 607,572 | 5,322 | 4.63 | 2620 |
| 8.2 | TO | 8.3 | 7 | 5,648 | 49 | 360 | 11490 | 613,220 | 5,372 | 4.67 | 2663 |
| 8.3 | TO | 8.4 | 5 | 3,642 | 32 | 365 | 8020 | 616,862 | 5,404 | 4.69 | 2692 |
| 8.4 | TO | 8.5 | 2 | 1,127 | 10 | 367 | 2050 | 617,989 | 5,414 | 4.69 | 2700 |
| 8.5 | TO | 8.6 | 5 | 5,040 | 44 | 372 | 9490 | 623,028 | 5,458 | 4.73 | 2741 |
| 8.6 | TO | 8.7 | 3 | 2,149 | 19 | 375 | 4300 | 625,177 | 5,477 | 4.74 | 2758 |
| 8.7 | TO | 8.8 | 4 | 2,967 | 26 | 379 | 5180 | 628,144 | 5,503 | 4.76 | 2782 |
| 8.8 | TO | 8.9 | 4 | 2,907 | 25 | 383 | 5030 | 631,050 | 5,528 | 4.78 | 2806 |
| 8.9 | TO | 9.0 | 1 | 761 | 7 | 384 | 1300 | 631,811 | 5,535 | 4.78 | 2812 |
| 9.0 | TO | 9.1 | 4 | 4,444 | 39 | 388 | 9380 | 636,255 | 5,574 | 4.81 | 2850 |
| 9.1 | TO | 9.2 | 1 | 1,260 | 11 | 389 | 2800 | 637,515 | 5,585 | 4.82 | 2861 |
| 9.2 | TO | 9.3 | 2 | 1,746 | 15 | 391 | 3510 | 639,261 | 5,600 | 4.83 | 2876 |
| 9.3 | TO | 9.4 | 1 | 754 | 7 | 392 | 1250 | 640,015 | 5,607 | 4.84 | 2882 |
| 9.4 | TO | 9.5 | 3 | 2,620 | 23 | 395 | 5750 | 642,635 | 5,629 | 4.86 | 2905 |
| 9.5 | TO | 9.6 | 4 | 2,318 | 20 | 399 | 4250 | 644,952 | 5,650 | 4.87 | 2926 |
| 9.6 | TO | 9.7 | 3 | 3,139 | 27 | 402 | 6680 | 648,092 | 5,677 | 4.90 | 2954 |
| 9.7 | TO | 9.8 | 5 | 2,906 | 25 | 407 | 5880 | 650,998 | 5,703 | 4.92 | 2980 |
| 9.8 | TO | 9.9 | 5 | 3,884 | 34 | 412 | 8010 | 654,882 | 5,737 | 4.95 | 3016 |
| 9.9 | TO | 10.0 | 1 | 806 | 7 | 413 | 1400 | 655,688 | 5,744 | 4.95 | 3023 |
| 10.0 | TO | 10.1 | 6 | 3,295 | 29 | 419 | 7560 | 658,983 | 5,773 | 4.98 | 3054 |

```
CAPACITIES REDUCED BY FIRMNESS, DOWN TIME AND TRANSMISSION LINE LOSSES                                           ON-GRID SITES (1st of 2 pages)
GRID    DISCOUNT RATE - 3 %    OPERATION AND MAINTENANCE RATE - 1.2 %          MANAGEMENT FEE - 8 %
WATER TAXES ARE NOT INCLUDED.  TRANSMISSION COST FACTOR NOT INCLUDED

 COST C/KWH   # SITES   CAPACITY   CAPACITY  TOTAL # SITES  INSTALLED CAPACITY  POWER CAPACITY  TOTAL CAPACITY  AV. COST/KWH   CUM. CAP. COST
                           KW         GWH                          KW                 KW             GWH           C/KWH       ($1,000,000)

 0.0  TO  0.1    0         0          0          0                 0                  0              0            0.00            0
 0.1  TO  0.2    0         0          0          0                 0                  0              0            0.00            0
 0.2  TO  0.3    0         0          0          0                 0                  0              0            0.00            0
 0.3  TO  0.4    0         0          0          0                 0                  0              0            0.00            0
 0.4  TO  0.5    0         0          0          0                 0                  0              0            0.00            0
 0.5  TO  0.6    0         0          0          0                 0                  0              0            0.00            0
 0.6  TO  0.7    0         0          0          0                 0                  0              0            0.00            0
 0.7  TO  0.8    0         0          0          0                 0                  0              0            0.00            0
 0.8  TO  0.9    0         0          0          0                 0                  0              0            0.00            0
 0.9  TO  1.0    0         0          0          0                 0                  0              0            0.00            0
 1.0  TO  1.1    0         0          0          0                 0                  0              0            0.00            0
 1.1  TO  1.2    0         0          0          0                 0                  0              0            0.00            0
 1.2  TO  1.3    0         0          0          0                 0                  0              0            0.00            0
 1.3  TO  1.4    0         0          0          0                 0                  0              0            0.00            0
 1.4  TO  1.5    0         0          0          0                 0                  0              0            0.00            0
 1.5  TO  1.6    0         0          0          0                 0                  0              0            0.00            0
 1.6  TO  1.7    0         0          0          0                 0                  0              0            0.00            0
 1.7  TO  1.8    0         0          0          0                 0                  0              0            0.00            0
 1.8  TO  1.9    1    14,723        129          1             28700             14,723            129            1.84           25
 1.9  TO  2.0    2     4,658         41          3              8700             19,381            170            1.87           34
 2.0  TO  2.1    0         0          0          3                 0             19,381            170            1.87           34
 2.1  TO  2.2    0         0          0          3                 0             19,381            170            1.87           34
 2.2  TO  2.3    0         0          0          3                 0             19,381            170            1.87           34
 2.3  TO  2.4    2    12,815        112          5             25700             32,196            282            2.05           62
 2.4  TO  2.5    2     5,678         50          7             11470             37,873            332            2.11           75
 2.5  TO  2.6    3     9,212         81         10             17900             47,086            412            2.20           97
 2.6  TO  2.7    6    20,253        177         16             35990             67,338            590            2.34          147
 2.7  TO  2.8    3     9,417         82         19             17100             76,756            672            2.39          172
 2.8  TO  2.9    7    22,600        198         26             43900             99,356            870            2.50          232
 2.9  TO  3.0    0         0          0         26                 0             99,356            870            2.50          232
 3.0  TO  3.1    2     5,511         48         28             10990            104,867            919            2.53          248
 3.1  TO  3.2    3     5,754         52         31             11060            110,821            971            2.56          265
 3.2  TO  3.3    8    16,453        144         39             32300            127,274          1,115            2.65          315
 3.3  TO  3.4    2     4,406         39         41              8300            131,679          1,154            2.67          329
 3.4  TO  3.5   12    20,975        184         53             40340            152,654          1,337            2.78          396
 3.5  TO  3.6    2    11,634        102         55             21740            164,288          1,439            2.83          434
 3.6  TO  3.7    5     7,592         67         60             15600            171,881          1,506            2.87          460
 3.7  TO  3.8    3     7,199         63         63             13790            179,079          1,569            2.90          485
 3.8  TO  3.9    5     7,619         67         68             15400            186,698          1,635            2.94          513
 3.9  TO  4.0    3     8,610         75         71             17900            195,308          1,711            2.99          544
 4.0  TO  4.1   11    26,612        233         82             51390            221,920          1,944            3.12          645
 4.1  TO  4.2    3     3,755         33         85              7680            225,675          1,977            3.13          660
 4.2  TO  4.3    3     4,314         38         88              8500            229,988          2,015            3.15          677
 4.3  TO  4.4    7    10,675         94         95             21480            240,663          2,108            3.21          720
 4.4  TO  4.5    3     4,896         43         98              9700            245,559          2,151            3.23          741
 4.5  TO  4.6    7    11,554        101        105             23330            257,113          2,252            3.29          789
 4.6  TO  4.7    9    21,630        189        114             42270            278,743          2,442            3.40          883
 4.7  TO  4.8    7    13,690        120        121             27220            292,433          2,562            3.46          943
 4.8  TO  4.9    5    11,097         97        126             24870            303,530          2,659            3.51          993
 4.9  TO  5.0    6     6,642         58        132             13920            310,173          2,717            3.54         1024
 5.0  TO  5.1    6     8,858         78        138             17800            319,031          2,795            3.56         1066
```

## ON-GRID SITES
(2nd of 2 pages)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.1 | TO | 5.2 | 5 | 5,521 | 48 | 143 | 11490 | 324,551 | 2,843 | 3.61 | 1092 |
| 5.2 | TO | 5.3 | 3 | 5,208 | 46 | 146 | 12100 | 329,760 | 2,889 | 3.64 | 1117 |
| 5.3 | TO | 5.4 | 2 | 1,825 | 16 | 148 | 3400 | 331,585 | 2,905 | 3.64 | 1126 |
| 5.4 | TO | 5.5 | 5 | 5,117 | 45 | 153 | 10560 | 336,702 | 2,950 | 3.67 | 1152 |
| 5.5 | TO | 5.6 | 3 | 2,044 | 18 | 156 | 4250 | 338,746 | 2,967 | 3.68 | 1163 |
| 5.6 | TO | 5.7 | 3 | 6,788 | 59 | 159 | 13220 | 345,533 | 3,027 | 3.72 | 1198 |
| 5.7 | TO | 5.8 | 4 | 3,436 | 30 | 163 | 6450 | 348,970 | 3,057 | 3.74 | 1217 |
| 5.8 | TO | 5.9 | 6 | 6,980 | 61 | 169 | 14020 | 355,949 | 3,118 | 3.78 | 1255 |
| 5.9 | TO | 6.0 | 4 | 6,127 | 54 | 173 | 10530 | 362,076 | 3,172 | 3.82 | 1288 |
| 6.0 | TO | 6.1 | 5 | 6,251 | 55 | 178 | 13570 | 368,327 | 3,227 | 3.86 | 1324 |
| 6.1 | TO | 6.2 | 9 | 9,855 | 86 | 187 | 20050 | 378,182 | 3,313 | 3.92 | 1380 |
| 6.2 | TO | 6.3 | 4 | 7,695 | 67 | 191 | 17290 | 385,877 | 3,380 | 3.96 | 1425 |
| 6.3 | TO | 6.4 | 11 | 13,967 | 122 | 202 | 23850 | 399,844 | 3,503 | 4.05 | 1507 |
| 6.4 | TO | 6.5 | 4 | 5,414 | 47 | 206 | 10650 | 405,258 | 3,550 | 4.08 | 1540 |
| 6.5 | TO | 6.6 | 6 | 4,228 | 37 | 212 | 9310 | 409,486 | 3,587 | 4.11 | 1565 |
| 6.6 | TO | 6.7 | 11 | 10,416 | 91 | 223 | 22120 | 419,902 | 3,678 | 4.17 | 1630 |
| 6.7 | TO | 6.8 | 12 | 14,361 | 126 | 235 | 30840 | 434,263 | 3,804 | 4.25 | 1721 |
| 6.8 | TO | 6.9 | 7 | 5,826 | 51 | 242 | 11130 | 440,089 | 3,855 | 4.29 | 1757 |
| 6.9 | TO | 7.0 | 7 | 6,667 | 58 | 249 | 13940 | 446,757 | 3,914 | 4.33 | 1800 |
| 7.0 | TO | 7.1 | 7 | 6,514 | 57 | 256 | 11390 | 453,271 | 3,971 | 4.37 | 1843 |
| 7.1 | TO | 7.2 | 5 | 7,218 | 63 | 261 | 14849 | 460,489 | 4,034 | 4.41 | 1891 |
| 7.2 | TO | 7.3 | 5 | 4,023 | 35 | 266 | 8100 | 464,512 | 4,069 | 4.44 | 1918 |
| 7.3 | TO | 7.4 | 3 | 3,955 | 35 | 269 | 8560 | 468,467 | 4,104 | 4.46 | 1945 |
| 7.4 | TO | 7.5 | 10 | 7,125 | 62 | 279 | 15260 | 475,591 | 4,166 | 4.50 | 1994 |
| 7.5 | TO | 7.6 | 4 | 3,028 | 27 | 283 | 5600 | 478,619 | 4,193 | 4.52 | 2016 |
| 7.6 | TO | 7.7 | 6 | 5,288 | 46 | 289 | 9360 | 483,907 | 4,239 | 4.56 | 2053 |
| 7.7 | TO | 7.8 | 7 | 6,951 | 61 | 296 | 13760 | 490,858 | 4,300 | 4.60 | 2103 |
| 7.8 | TO | 7.9 | 4 | 2,412 | 21 | 300 | 4450 | 493,271 | 4,321 | 4.62 | 2121 |
| 7.9 | TO | 8.0 | 6 | 4,599 | 40 | 306 | 9430 | 497,870 | 4,361 | 4.65 | 2154 |
| 8.0 | TO | 8.1 | 4 | 3,149 | 28 | 310 | 6280 | 501,019 | 4,389 | 4.67 | 2178 |
| 8.1 | TO | 8.2 | 3 | 3,633 | 32 | 313 | 6990 | 504,653 | 4,421 | 4.70 | 2206 |
| 8.2 | TO | 8.3 | 7 | 5,647 | 49 | 320 | 11490 | 510,300 | 4,470 | 4.74 | 2249 |
| 8.3 | TO | 8.4 | 5 | 3,642 | 32 | 325 | 8020 | 513,943 | 4,502 | 4.76 | 2277 |
| 8.4 | TO | 8.5 | 2 | 1,127 | 10 | 327 | 2050 | 515,069 | 4,512 | 4.77 | 2286 |
| 8.5 | TO | 8.6 | 4 | 3,834 | 34 | 331 | 7430 | 518,904 | 4,546 | 4.80 | 2316 |
| 8.6 | TO | 8.7 | 3 | 2,149 | 19 | 334 | 4300 | 521,053 | 4,564 | 4.81 | 2334 |
| 8.7 | TO | 8.8 | 4 | 2,967 | 26 | 338 | 5180 | 524,019 | 4,590 | 4.84 | 2358 |
| 8.8 | TO | 8.9 | 3 | 1,836 | 16 | 341 | 3200 | 525,855 | 4,606 | 4.85 | 2373 |
| 8.9 | TO | 9.0 | 1 | 760 | 7 | 342 | 1300 | 526,616 | 4,613 | 4.86 | 2379 |
| 9.0 | TO | 9.1 | 3 | 3,594 | 31 | 345 | 7280 | 530,210 | 4,645 | 4.88 | 2410 |
| 9.1 | TO | 9.2 | 1 | 1,260 | 11 | 346 | 2800 | 531,470 | 4,656 | 4.89 | 2421 |
| 9.2 | TO | 9.3 | 2 | 1,746 | 15 | 348 | 3510 | 533,216 | 4,671 | 4.91 | 2436 |
| 9.3 | TO | 9.4 | 1 | 754 | 7 | 349 | 1250 | 533,969 | 4,678 | 4.91 | 2442 |
| 9.4 | TO | 9.5 | 3 | 2,620 | 23 | 352 | 5750 | 536,589 | 4,701 | 4.94 | 2465 |
| 9.5 | TO | 9.6 | 4 | 2,318 | 20 | 356 | 4250 | 538,907 | 4,721 | 4.96 | 2486 |
| 9.6 | TO | 9.7 | 2 | 2,917 | 26 | 358 | 6300 | 541,824 | 4,746 | 4.98 | 2512 |
| 9.7 | TO | 9.8 | 5 | 2,906 | 25 | 363 | 5880 | 544,730 | 4,772 | 5.01 | 2538 |
| 9.8 | TO | 9.9 | 4 | 3,241 | 28 | 367 | 6910 | 547,971 | 4,800 | 5.04 | 2568 |
| 9.9 | TO | 10.0 | 1 | 806 | 7 | 368 | 1400 | 548,777 | 4,807 | 5.04 | 2576 |
| 10.0 | TO | 10.1 | 5 | 2,471 | 22 | 373 | 5090 | 551,248 | 4,829 | 5.07 | 2599 |

4

# APPENDIX 3

# APPENDIX 3

## PEACE SITE C COST ANALYSIS

**Presented for:**

1. Assumption that there is a market for all available power.
2. Assuming that power is sold only to meet domestic demand.

**Assumptions:**

1. Discount rate of 8 percent.
2. Costs are in October 1982 dollars.
3. Costs and capacities supplied by BC Hydro (Jan 1983).
4. Load growth forecast based on MEMPR forecast (Reference 6).
5. 50 year time horizon.
6. In-service date of February 1991.
7. Water taxes not included.
8. Property and school taxes not included.

**** POWER COST ANALYSIS FOR PEACE SITE C ****

1. Power Cost for Site C Assuming Sale of all Power

DISCOUNT RATE = 8.00 VALUE OF EXPORT POWER (MILLS/KWH) = .00

CONSTRUCTION MANAGEMENT COSTS (%) = 5.00

| YEAR | DOMESTIC POWER (GWH/YR) | EXPORT POWER (GWH) | TOTAL POWER (GWH) | DISCOUNTED DOMESTIC POWER (GWH) | VALUE EXPORT POWER ($M) | PV VALUE EXPORT POWER ($M) | CONSTRUCTION COSTS GENERATION ($M) | TRANSMISSION ($M) | TOTAL ($M) | PV ($M) | OPERATION AND MAINTENANCE ($M) | PV OPER. AND MAINT. ($M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | .00 | .00 | .00 | .00 | .00 | .00 | 41.50 | 1.10 | 42.40 | 12.60 | | .00 |
| 1983 | .00 | .00 | .00 | .00 | .00 | .00 | 3.74 | .24 | 4.18 | 3.87 | | .00 |
| 1984 | .00 | .00 | .00 | .00 | .00 | .00 | 33.91 | .31 | 35.94 | 30.81 | | .00 |
| 1985 | .00 | .00 | .00 | .00 | .00 | .00 | 114.50 | 1.59 | 121.89 | 96.76 | | .00 |
| 1986 | .00 | .00 | .00 | .00 | .00 | .00 | 158.65 | 7.15 | 174.08 | 127.96 | | .00 |
| 1987 | .00 | .00 | .00 | .00 | .00 | .00 | 135.91 | 9.71 | 152.90 | 104.06 | | .00 |
| 1988 | .00 | .00 | .00 | .00 | .00 | .00 | 263.95 | 28.15 | 306.71 | 193.28 | | .00 |
| 1989 | .00 | .00 | .00 | .00 | .00 | .00 | 349.61 | 61.01 | 431.14 | 251.57 | | .00 |
| 1990 | .00 | .00 | .00 | .00 | .00 | .00 | 247.25 | 41.35 | 304.17 | 165.41 | 6.70 | 3.62 |
| 1991 | 3295.00 | .00 | 3295.00 | 1640.32 | .00 | .00 | 34.72 | 11.32 | 48.33 | 24.18 | 6.70 | 3.35 |
| 1992 | 4770.00 | .00 | 4770.00 | 2209.43 | .00 | .00 | 3.20 | .00 | 3.36 | 1.56 | 6.70 | 3.10 |
| 1993 | 4770.00 | .00 | 4770.00 | 2045.77 | .00 | .00 | .90 | .00 | .95 | .41 | 6.70 | 2.87 |
| 1994 | 4770.00 | .00 | 4770.00 | 1894.23 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.66 |
| 1995 | 4770.00 | .00 | 4770.00 | 1753.92 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.46 |
| 1996 | 4770.00 | .00 | 4770.00 | 1624.00 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.28 |
| 1997 | 4770.00 | .00 | 4770.00 | 1503.70 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.11 |
| 1998 | 4770.00 | .00 | 4770.00 | 1392.32 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 1.96 |
| 1999 | 4770.00 | .00 | 4770.00 | 1289.18 | .00 | .00 | | | | | 6.70 | 1.81 |
| 2000 | 4770.00 | .00 | 4770.00 | 1193.49 | .00 | .00 | | | | | 6.70 | 1.68 |
| 2001 | 4770.00 | .00 | 4770.00 | 1105.27 | .00 | .00 | | | | | 6.70 | 1.55 |
| 2002 | 4770.00 | .00 | 4770.00 | 1023.39 | .00 | .00 | | | | | 6.70 | 1.44 |
| 2003 | 4770.00 | .00 | 4770.00 | 947.59 | .00 | .00 | | | | | 6.70 | 1.33 |
| 2004 | 4770.00 | .00 | 4770.00 | 877.40 | .00 | .00 | | | | | 6.70 | 1.23 |
| 2005 | 4770.00 | .00 | 4770.00 | 812.40 | .00 | .00 | | | | | 6.70 | 1.14 |
| 2006 | 4770.00 | .00 | 4770.00 | 752.23 | .00 | .00 | | | | | 6.70 | 1.06 |
| 2007 | 4770.00 | .00 | 4770.00 | 696.51 | .00 | .00 | | | | | 6.70 | .98 |
| 2008 | 4770.00 | .00 | 4770.00 | 644.91 | .00 | .00 | | | | | 6.70 | .91 |
| 2009 | 4770.00 | .00 | 4770.00 | 597.14 | .00 | .00 | | | | | 6.70 | .84 |
| 2010 | 4770.00 | .00 | 4770.00 | 552.91 | .00 | .00 | | | | | 6.70 | .78 |
| 2011 | 4770.00 | .00 | 4770.00 | 511.95 | .00 | .00 | | | | | 6.70 | .72 |
| 2012 | 4770.00 | .00 | 4770.00 | 474.03 | .00 | .00 | | | | | 6.70 | .67 |
| 2013 | 4770.00 | .00 | 4770.00 | 438.92 | .00 | .00 | | | | | 6.70 | .62 |
| 2014 | 4770.00 | .00 | 4770.00 | 406.40 | .00 | .00 | | | | | 6.70 | .57 |
| 2015 | 4770.00 | .00 | 4770.00 | 376.30 | .00 | .00 | | | | | 6.70 | .53 |
| 2016 | 4770.00 | .00 | 4770.00 | 348.43 | .00 | .00 | | | | | 6.70 | .49 |
| 2917 | 4770.00 | .00 | 4770.00 | 322.62 | .00 | .00 | | | | | 6.70 | .45 |
| 2018 | 4770.00 | .00 | 4770.00 | 298.72 | .00 | .00 | | | | | 6.70 | .42 |
| 2019 | 4770.00 | .00 | 4770.00 | 276.59 | .00 | .00 | | | | | 6.70 | .39 |
| 2020 | 4770.00 | .00 | 4770.00 | 256.10 | .00 | .00 | | | | | 6.70 | .36 |
| 2021 | 4770.00 | .00 | 4770.00 | 237.13 | .00 | .00 | | | | | 6.70 | .33 |
| 2022 | 4770.00 | .00 | 4770.00 | 219.57 | .00 | .00 | | | | | 6.70 | .31 |
| 2023 | 4770.00 | .00 | 4770.00 | 203.30 | .00 | .00 | | | | | 6.70 | .29 |
| 2024 | 4770.00 | .00 | 4770.00 | 188.24 | .00 | .00 | | | | | 6.70 | .26 |
| 2025 | 4770.00 | .00 | 4770.00 | 174.30 | .00 | .00 | | | | | 6.70 | .24 |
| 2026 | 4770.00 | .00 | 4770.00 | 161.39 | .00 | .00 | | | | | 6.70 | .23 |
| 2027 | 4770.00 | .00 | 4770.00 | 149.43 | .00 | .00 | | | | | 6.70 | .21 |
| 2028 | 4770.00 | .00 | 4770.00 | 138.36 | .00 | .00 | | | | | 6.70 | .19 |
| 2029 | 4770.00 | .00 | 4770.00 | 128.12 | .00 | .00 | | | | | 6.70 | .18 |
| 2030 | 4770.00 | .00 | 4770.00 | 118.63 | .00 | .00 | | | | | 6.70 | .17 |
| 2031 | 4770.00 | .00 | 4770.00 | 109.84 | .00 | .00 | | | | | 6.70 | .15 |
| 2032 | 4770.00 | .00 | 4770.00 | 101.70 | .00 | .00 | | | | | 6.70 | .14 |

```
2033  4770.00    .00  4770.00     94.17     .00    .00                                          6.70    .13
2034  4770.00    .00  4770.00     87.19     .00    .00                                          6.70    .12
2035  4770.00    .00  4770.00     80.73     .00    .00                                          6.70    .11
2036  4770.00    .00  4770.00     74.75     .00    .00                                          6.70    .11
2037  4770.00    .00  4770.00     69.72     .00    .00                                          6.70    .10
2038  4770.00    .00  4770.00     64.09     .00    .00                                          6.70    .09
2039  4770.00    .00  4770.00     59.34     .00    .00                                          6.70    .06
                                --------         --------   --------  --------  --------  --------          --------
TOTALS =                        26354.70             .00    1387.82    164.91   1678.24   1042.45             47.83
                                ========         ========   ========  ========  ========  ========          ========


PV NET COST OF DOMESTIC POWER:
  PV CAPITAL COSTS               1042.45
  PLUS PV O & M COSTS              47.83
  LESS PV EXPORT POWER               .00
                                --------
                                 1090.28     PV COST OF DOMESTIC POWER PER KWH = PV NET COST / DISCOUNTED DOMESTIC POWER
                                ========
                                                                   =          41.37 MILLS
                                                                              ================
```

## 2. Power Cost of Site C Assuming Sale of Power for Domestic Demand Only

**** POWER COST ANALYSIS FOR PEACE SITE C ****

DISCOUNT RATE = 8.00 VALUE OF EXPORT POWER (MILLS/KWH) = .00

CONSTRUCTION MANAGEMENT COSTS (%) = 5.00

| YEAR | DOMESTIC POWER (GWH/YR) | EXPORT POWER (GWH) | TOTAL POWER (GWH) | DISCOUNTED DOMESTIC POWER (GWH) | VALUE EXPORT POWER ($M) | PV VALUE EXPORT POWER ($M) | CONSTRUCTION COSTS | | | | OPERATION AND MAINTENANCE ($M) | PV OPER. AND MAINT. ($M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | GENERATION ($M) | TRANSMISSION ($M) | TOTAL ($M) | PV ($M) | | |
| 1982 | .00 | .00 | .00 | .00 | .00 | .00 | 41.50 | 1.10 | 42.60 | 42.60 | | .00 |
| 1983 | .00 | .00 | .00 | .00 | .00 | .00 | 3.74 | .24 | 4.18 | 3.87 | | .00 |
| 1984 | .00 | .00 | .00 | .00 | .00 | .00 | 33.91 | .31 | 35.94 | 30.81 | | .00 |
| 1985 | .00 | .00 | .00 | .00 | .00 | .00 | 114.50 | 1.59 | 121.89 | 96.76 | | .00 |
| 1986 | .00 | .00 | .00 | .00 | .00 | .00 | 158.65 | 7.15 | 174.08 | 127.96 | | .00 |
| 1987 | .00 | .00 | .00 | .00 | .00 | .00 | 135.91 | 9.71 | 152.90 | 104.06 | | .00 |
| 1988 | .00 | .00 | .00 | .00 | .00 | .00 | 263.95 | 28.15 | 306.71 | 193.28 | | .00 |
| 1989 | .00 | .00 | .00 | .00 | .00 | .00 | 349.61 | 61.01 | 431.14 | 251.57 | | .00 |
| 1990 | .00 | .00 | .00 | .00 | .00 | .00 | 247.25 | 44.35 | 306.17 | 165.41 | 6.70 | 3.62 |
| 1991 | 1111.00 | 2184.00 | 3295.00 | 555.78 | .00 | .00 | 34.77 | 11.32 | 48.33 | 24.18 | 6.70 | 3.35 |
| 1992 | 1944.00 | 2826.00 | 4770.00 | 900.45 | .00 | .00 | 3.20 | .00 | 3.36 | 1.56 | 6.70 | 3.10 |
| 1993 | 2500.00 | 2270.00 | 4770.00 | 1072.21 | .00 | .00 | .90 | .00 | .95 | .41 | 6.70 | 2.87 |
| 1994 | 3056.00 | 1714.00 | 4770.00 | 1213.58 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.66 |
| 1995 | 3889.00 | 881.00 | 4770.00 | 1429.98 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.46 |
| 1996 | 4770.00 | .00 | 4770.00 | 1624.00 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.28 |
| 1997 | 4770.00 | .00 | 4770.00 | 1503.70 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 2.11 |
| 1998 | 4770.00 | .00 | 4770.00 | 1392.32 | .00 | .00 | .00 | .00 | .00 | .00 | 6.70 | 1.96 |
| 1999 | 4770.00 | .00 | 4770.00 | 1289.18 | .00 | .00 | | | | | 6.70 | 1.81 |
| 2000 | 4770.00 | .00 | 4770.00 | 1193.69 | .00 | .00 | | | | | 6.70 | 1.68 |
| 2001 | 4770.00 | .00 | 4770.00 | 1105.27 | .00 | .00 | | | | | 6.70 | 1.55 |
| 2002 | 4770.00 | .00 | 4770.00 | 1023.39 | .00 | .00 | | | | | 6.70 | 1.44 |
| 2003 | 4770.00 | .00 | 4770.00 | 947.59 | .00 | .00 | | | | | 6.70 | 1.33 |
| 2004 | 4770.00 | .00 | 4770.00 | 877.40 | .00 | .00 | | | | | 6.70 | 1.23 |
| 2005 | 4770.00 | .00 | 4770.00 | 812.40 | .00 | .00 | | | | | 6.70 | 1.14 |
| 2006 | 4770.00 | .00 | 4770.00 | 752.23 | .00 | .00 | | | | | 6.70 | 1.06 |
| 2007 | 4770.00 | .00 | 4770.00 | 696.51 | .00 | .00 | | | | | 6.70 | .98 |
| 2008 | 4770.00 | .00 | 4770.00 | 644.91 | .00 | .00 | | | | | 6.70 | .91 |
| 2009 | 4770.00 | .00 | 4770.00 | 597.14 | .00 | .00 | | | | | 6.70 | .84 |
| 2010 | 4770.00 | .00 | 4770.00 | 552.91 | .00 | .00 | | | | | 6.70 | .78 |
| 2011 | 4770.00 | .00 | 4770.00 | 511.95 | .00 | .00 | | | | | 6.70 | .72 |
| 2012 | 4770.00 | .00 | 4770.00 | 474.03 | .00 | .00 | | | | | 6.70 | .67 |
| 2013 | 4770.00 | .00 | 4770.00 | 438.92 | .00 | .00 | | | | | 6.70 | .62 |
| 2014 | 4770.00 | .00 | 4770.00 | 406.40 | .00 | .00 | | | | | 6.70 | .57 |
| 2015 | 4770.00 | .00 | 4770.00 | 376.30 | .00 | .00 | | | | | 6.70 | .53 |
| 2016 | 4770.00 | .00 | 4770.00 | 348.43 | .00 | .00 | | | | | 6.70 | .49 |
| 2017 | 4770.00 | .00 | 4770.00 | 322.62 | .00 | .00 | | | | | 6.70 | .45 |
| 2018 | 4770.00 | .00 | 4770.00 | 298.72 | .00 | .00 | | | | | 6.70 | .42 |
| 2019 | 4770.00 | .00 | 4770.00 | 276.59 | .00 | .00 | | | | | 6.70 | .39 |
| 2020 | 4770.00 | .00 | 4770.00 | 256.10 | .00 | .00 | | | | | 6.70 | .36 |
| 2021 | 4770.00 | .00 | 4770.00 | 237.13 | .00 | .00 | | | | | 6.70 | .33 |
| 2022 | 4770.00 | .00 | 4770.00 | 219.57 | .00 | .00 | | | | | 6.70 | .31 |
| 2023 | 4770.00 | .00 | 4770.00 | 203.30 | .00 | .00 | | | | | 6.70 | .29 |
| 2024 | 4770.00 | .00 | 4770.00 | 188.24 | .00 | .00 | | | | | 6.70 | .26 |
| 2025 | 4770.00 | .00 | 4770.00 | 174.30 | .00 | .00 | | | | | 6.70 | .24 |
| 2026 | 4770.00 | .00 | 4770.00 | 161.39 | .00 | .00 | | | | | 6.70 | .23 |
| 2027 | 4770.00 | .00 | 4770.00 | 149.43 | .00 | .00 | | | | | 6.70 | .21 |
| 2028 | 4770.00 | .00 | 4770.00 | 138.36 | .00 | .00 | | | | | 6.70 | .19 |
| 2029 | 4770.00 | .00 | 4770.00 | 128.12 | .00 | .00 | | | | | 6.70 | .18 |
| 2030 | 4770.00 | .00 | 4770.00 | 118.63 | .00 | .00 | | | | | 6.70 | .17 |
| 2031 | 4770.00 | .00 | 4770.00 | 109.84 | .00 | .00 | | | | | 6.70 | .15 |
| 2032 | 4770.00 | .00 | 4770.00 | 101.70 | .00 | .00 | | | | | 6.70 | .14 |

```
2033  4770.00      .00  4770.00        74.17         .00     .00                                                     6.70     .13
2034  4770.00      .00  4770.00        87.19         .00     .00                                                     6.70     .12
2035  4770.00      .00  4770.00        80.73         .00     .00                                                     6.70     .11
2036  4770.00      .00  4770.00        74.75         .00     .00                                                     6.70     .11
2037  4770.00      .00  4770.00        69.72         .00     .00                                                     6.70     .10
2038  4770.00      .00  4770.00        64.09         .00     .00                                                     6.70     .09
2039  4770.00      .00  4770.00        59.34         .00     .00                                                     6.70     .08
                                    --------            --------   --------   --------   --------   --------                 --------
TOTALS =                            30733.89                 .00    1387.87     164.91    1678.24    1042.45                    47.83
                                    ========            ========   ========   ========   ========   ========                 ========


PV NET COST OF DOMESTIC POWER:
  PV CAPITAL COSTS                   1042.45
  PLUS PV O & M COSTS                  47.83
  LESS PV EXPORT POWER                   .00
                                    --------
                                     1090.28      PV COST OF DOMESTIC POWER PER KWH = PV NET COST / DISCOUNTED DOMESTIC POWER
                                    ========
                                                                      =           35.47 MILLS
                                                                                ===============
```

# APPENDIX 4

## APPENDIX 4

## DETAILED CAPITAL COSTING METHODOLOGY

This model was programmed on a "Supercalc" computerized worksheet for the Resource Assessment (Reference 1). Its purpose was to assess the costs and capacities of the selected small hydro power sites. This model required 12 input variables as described below:

| | | |
|---|---|---|
| Intake Elevation (in metres) | - | from topographic mapping |
| Powerhouse Elevation (in metres) | - | from topographic mapping |
| Design Flow (in cubic metres/sec) | - | estimated mean annual flow (MAF) was used as this was generally found to be the most optimum point, although the range from 60 percent MAF to 200 percent MAF is generally acceptable |
| Horizontal Penstock Length (metres) | - | measured penstock length from topographic mapping |
| Site Factor | - | a factor applied to the costs of certain items to account for the remoteness/accessibility of the small hydro site. A factor of 1.0 would be applied for sites around areas like Vancouver and a factor of up to 1.5 could be applied for remote areas such as the Queen Charlotte Islands. |
| Access Road Length | - | length of access road required to reach the power house |
| Uncertainty about Design Flow | - | 90 percent probable ± range of flow. Depends on the available knowledge of the area |
| Factor Fraction of Possible kW.h | - | firmness of creek based on MAF. A computer program (run on the Boeing computer in Seattle) was developed to use available stream flow records at about 75 selected sites to construct a map of firmness for British Columbia (a smaller, simplified firmness map was included in the Phase 1 study report) |

Uncertainty about Factor Fraction - 90 percent probable ± range of firmness. Depends on the available knowledge of the area

Nearest Distribution Line Rating (in kV)

Distance to Distribution Line (in km) - distance measured (on topographic map) to nearest distribution line. If the nearest distribution line had a high kV rating and the site was small, then the next nearest low kV line was chosen. The suitability of the transmission line to accept the power has not been checked at this level of study.

Available Storage - (as percentage of basin)

The following variables were then determined by the computer program.

1. Gross head (m) = Intake Elevation - Power house elevation

   **Remarks:** - self explanatory

2. Average Slope of Penstock = Gross Head/Length of Penstock

   **Remarks:** - self explanatory

3. Penstock Length - SQRT ( $(\text{Gross Head})^2 + (\text{Horizontal Length of Penstock})^2$ )

   **Remarks:** - actual length varied little from measured horizontal length except for penstocks having a steep gradient.

4. Calculated Penstock Diameter = $(0.43182) \times \left( (\text{Design Flow})^2 \times (\text{Penstock Length})/(\text{Gross Head})\right)^{(3/16)}$

   **Remarks:** - a penstock diameter was selected to yield a net head equal to 90 percent of the gross head (fairly standard practice for preliminary design). Mannings equation was used with $n = 0.0105$ for steel.

5. Nearest Available Penstock Diameter - a lookup table was used

   **Remarks:** - closest steel penstock diameter available from one local supplier was chosen.

6. Net Head = Gross Head - $(0.001135) \times (\text{Design Flow})^2 / (\text{Available Diameter})^{(16/3)} \times (\text{Penstock Length})$

   **Remarks:** - this is the actual net head obtained when the nearest available penstock diameter was used (based on Mannings equation with $n = 0.0105$).

7. Thickness Factor - a lookup table was used

Remarks: - this factor is applied to the maximum thickness required by the penstock to determine an average thickness. A different thickness factor is used for each increment of 50 metres of head. This assumes that the thickness of the penstock will increase from the intake to the power house.

8. Minimum Thickness - a lookup table was used

Remarks: - this is the suppliers minimum thickness required for safe handling.

9. Average Thickness Calculated = 6.191 x $(10)^{(-5)}$ x (Gross head) x (Available Diameter) x (Thickness Factor)

Remarks: - the hoop stress formula was used with a safety factor of 1.3 to account for water hammer effects.

10. Volume of Steel Penstock =( $(\text{Penstock Thickness})^2$ + (Penstock Thickness) x (Available Diameter)) x PI x (Penstock Length)

Remarks: - penstock thickness used is the greater of the minimum thickness available and the average thickness calculated.

11. Additional Costs due to Slope = 1 + (Slope of Penstock - .15) for slope greater than or equal to 15%

Remarks: - adds 1% to cost of penstock for every additional 1% of slope in excess of 15%.

12. Plant Capacity = (Design Flow) x (Net Head) x 8

Remarks: - this assumes a plant efficiency of 81% and a specific gravity of water equal to 9810 $N/m^3$

13. Economy of Scale Factor = 5 x $(\text{Plant Capacity})^{(-0.16)}$

Remarks: - this is an empirical equation developed to account for the economies of scale seen in hydro projects.

14. Cost of Penstock = (Volume of Penstock in $m^3$) x (Slope Factor) x (7850 kg/$m^3$ (density of steel) ) x (Site Factor) x (\$4/kg) x (1.62 x (Diameter)$^{(0.0845)}$ )

**Remarks:** the last term is an empirical economy of scale factor for penstocks. The previous economy of scale factor is not used here as diameter is more important than plant capacity which relies on flow (related to diameter) and head.

15. Intake Cost = ( (Design Flow) x 34,293 + 17,342)
x (Economy of Scale Factor) x (Site Factor)

**Remarks:** - Based on empirical equation from previous experience

16. Generating Equipment Cost = 16,000 x (Plant Capacity)$^{(0.7)}$
x (Net Head)$^{(-0.35)}$ ) for projects less than 5 MW
= 1.43 x (10)$^6$ x ( (Plant Capacity / 1000) )$^{(0.92)}$
x ( (Net Head)$^{(-0.32)}$ x (Plant Capacity / 1000)$^{(0.058)}$ ) ) )

**Remarks:** - equation is based on an article entitled "Quick Estimating Techniques for Small Hydro Potential" Water Power and Dam Construction, September 1979. Costs were brought forward to 1982 Canadian Dollars.

17. Turbine Speed and Type Code - a lookup table was used

**Remarks:** - the program selected a turbine type and specific speed based on gross head and plant capacity. The turbine speed was generally chosen to be as fast as technically possible to reduce turbine and generator size which would reduce the size and cost of the power house.

18. Turbine Speed = Integer of (Turbine Speed and Type Code) x 10

**Remarks:** See #17 above.

19. Turbine Type = 0.75 for Francis turbine
= 0.45 for Pelton

20. Power House Length = (SQRT (Net Head) x (126)/(Turbine Speed) + 3.7)
for Pelton

= (SQRT (Net Head) x 385/(Turbine Speed) + 3.7)
for Francis

**Remarks:** - this dimension is dependent on the turbine principal dimension which is the turbine throat. An additional 3.7 metres is provided for clearance requirements.

21. Powerhouse Width = (SQRT (Net Head) x 73.6/(Turbine Speed) + 2.1 + 4
x (Available Penstock Diameter) )
for Pelton turbine

= (SQRT (Net Head) x 228/(Turbine Speed) + 2.1 + 4
x (Available Penstock Diameter))
for Francis turbine

**Remarks: -** this dimension is dependent on the turbine throat and the penstock diameter. An additional 2.1 metres is provided for clearance requirements.

22. Power House Cost = (Powerhouse Width) x (Power House Length) x (Economy of Scale Factor) x (Site Factor) x ($1600/m$^2$)

**Remarks: -** empirical, based on previous experience.

23. Access Road Cost = (Access Road Length) x (13000 + 9592 x ln (Plant Capacity) )

**Remarks: -** as the hydro plant gets larger, the access road must become better, so cost/km goes up. A small plant may have an access road that costs $45,000/km where a large plant may have an access road that costs $110,000/km.

24. Contingencies Cost - 30% added to cost of project

**Remarks: -** at this level of study, a factor of 30% was required to account for grid tie-in ( 5%) and any unforeseen problems.

25. Engineering Cost = (0.12) x (Economy of Scale Factor) x (Capital Cost including Contingencies)

**Remarks: -** accounts for varying amount of engineering required for projects of different size. A small project might require the engineering cost to be 30% of the capital cost whereas a large project might require an engineering cost of only 8%.

26. Transmission Line Cost - not included in the Phase 1 study report

**Remarks: -** this is included in the Phase 2 study as part of the total capital cost. The cost/km of transmission line depends on the distance and the amount of power to be transmitted. Transmission line costs vary from $50,000/km to $80,000/km.

27. Capital Cost (without transmission)

**Remarks:** - Computed based on the above formulas.

28. Capital Cost (with transmission)

**Remarks:** - computed based on the above formulas

29. Total kW.h/year = (Firmness Factor) x (Plant Capacity) x (8760 hrs/yr)

**Remarks** - this study also includes a factor of 0.85 to account for transmission line losses (5%) and down time losses (10%).

# APPENDIX 5

## APPENDIX 5

## BC HYDRO SYSTEM AND POWER DEMAND FORECAST

The method used to derive the MEMPR forecast for the BC Hydro System is summarized as follows:

- The provincial gross electricity requirements are presented in Table 9.1, page 9-2 of the latest forecast (Reference 6) at five year intervals from 1980 to 1995.
- From the gross requirements was subtracted the supply of electricity from non-BC Hydro sources which was inferred from Table 8.3, page 8-9. In 1985 and thereafter, a total of 41.4 PJ (11,500 GW.h) was subtracted from gross requirements on the BC Hydro system only. Since the supply of non-BC Hydro electricity remains constant after 1985, then all of the growth in requirements is on the BC Hydro system.
- The MEMPR forecast, given in five year intervals, was converted to an annual forecast by assuming a constant growth rate over the intervening years.
- The electricity supply forecast was taken from Table 8.3, page 8-9, assuming average water conditions and with an in-service date of 1984 for the Revelstoke Project. Throughout, petajoules were assumed equivalent to 277.78 GW.h.
- The resulting forecast is presented in the following table, Column 1. If we take the small hydro potential to be 1,377 GW.h, then this is sufficient to meet two years plus of load growth.

It must be emphasized that the purpose of the discussion in the report was to illustrate the flexibility of small hydro power development that was not captured in other analyses (e.g. with regard to planning system additions and in matching load growth). These features apply no matter what forecast is assumed. However, this flexibility is clearly more significant during low growth periods.

## B. C. HYDRO

## COMPARISON OF ACTUAL ENERGY REQUIREMENTS WITH PROBABLE FORECAST OF TOTAL GROSS REQUIREMENTS (%)**

| | YEARS AFTER FORECAST | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1963 (probable) | 0.1 | -3.5 | -10.8 | -17.3 | -20.5 | -24.8 | -25.7 | -28.1 | -31.4 | -35.6 | -38.0 |
| 1964 (probable) | -1.6 | -4.1 | -7.6 | -9.0 | -14.4 | -15.7 | -18.1 | -22.8 | -27.6 | -31.3 | -30.3 |
| 1965 (probable) | -1.8 | -4.4 | -1.0 | -3.6 | -4.5 | -6.6 | -11.6 | -18.5 | -22.7 | -22.4 | -19.5 |
| 1966 (probable) | -0.1 | 2.7 | 2.0 | -0.5 | 0.1 | -5.6 | N/A | N/A | N/A | N/A | N/A |
| 1967 (probable) | 0.4 | 0.2 | 1.3 | -0.2 | -3.8 | -9.5 | N/A | N/A | N/A | N/A | N/A |
| 1968 (probable) | -1.6 | -1.9 | -0.4 | -2.6 | -8.4 | -11.7 | N/A | N/A | N/A | N/A | N/A |
| 1969 (probable) | 0.1 | 1.9 | -0.9 | -4.4 | -9.0 | -7.4 | -2.8 | -7.0 | -7.1 | -7.4 | -3.0 |
| 1970 (single) | -0.8 | 4.2 | 1.8 | 1.3 | 5.6 | 12.1* | 9.6* | 11.4* | 12.9* | 19.6* | 25.5* |
| 1971 (single) | 0.6 | 0.9 | 1.2 | 6.7 | 14.7 | 12.5* | 15.0* | 16.5* | 23.8* | 29.5* | 35.7* |
| 1972 (single) | -1.8 | -1.4 | 2.8 | 12.1 | 11.1 | 14.4* | 16.8* | 23.9* | 29.3* | 35.6* | |
| 1973 (single) | 0.5 | 4.8 | 14.0 | 12.9 | 17.7 | 20.5* | 29.5* | 36.7* | 43.5* | | |
| 1974 (single) | -0.5 | 5.3 | 5.3 | 12.7 | 16.7 | 25.2* | 31.2* | 38.9* | | | |
| 1975 (single) | -0.6 | 2.2 | 5.0 | 9.9 | 18.6 | 26.1* | 32.6* | | | | |
| 1976 (probable) | 0.7 | 3.4 | 4.7 | 11.3 | 18.5 | 24.8 | | | | | |
| 1977 (probable) | 0.4 | -0.8 | 2.3 | 5.1 | 7.3 | | | | | | |
| 1978 (probable) | -1.4 | 2.0 | 2.8 | 5.3 | | | | | | | |
| 1979 (probable) | 1.2 | 3.0 | 7.6 | | | | | | | | |
| 1980 (probable) | 0.9 | 5.6 | | | | | | | | | |
| 1981 (probable) | -0.1 | | | | | | | | | | |

* High forecast.

** Difference between forecast made 1 to 11 years prior to year indicated divided by actual. A negative sign indicates forecast is too low.

## ELECTRICITY REQUIREMENTS BALANCE
## (B.C. HYDRO SYSTEM ONLY)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | Gross Requirements[1] (EMPR) | Supply[2] | Supply Deficit | Gross Requirements[3] (BCHPA) | Supply Deficit | Small Hydro[4] (EMPR) | Small Hydro (BCHPA) |
| 1980 | 30,306 | | | 30,996 | | | |
| 1985 | 39,639 | 47,778 | - | 37,875 | - | | |
| 1986 | 40,988[5] | | - | 40,100 | - | | |
| 1987 | 42,383[5] | | - | 41,920 | - | | |
| 1988 | 43,826[5] | | - | 43,440 | - | | |
| 1989 | 45,318[5] | | - | 45,120 | - | | |
| 1990 | 46,861 | | - | 47,060 | - | | |
| 1991 | 47,510[5] | | - | 49,330 | 1,552 | | 1,371 |
| 1992 | 48,167[5] | | 389 | 50,900 | 3,122 | 389 | |
| 1993 | 48,834[5] | | 1,056 | 52,600 | 4,822 | 1,056 | |
| 1994 | 49,509[5] | | 1,731 | | | 1,377 | |
| 1995 | 50,195 | | 2,417 | | | | |

1. MEMPR, April 1981, Table 9.1 Net of Non-BCHPA Supplies in Table 8.3
2. Includes Revelstoke capacity/firm energy supply
3. B.C. Hydro & Power Authority; Projection of Gross Load Requirements, September, 1982, pg. 125, table 7-3.
4. From draft Economic and Financial Assessment, assumes small hydro potential of 11,377 GWh/yr.
5. Values estimated by interpolation

Number/
Numéro
2

# SMALL HYDRO POWER RESOURCE IN THE PROVINCIAL SYSTEM

## Technology & Resource Assessment

**Canadian Cataloguing in Publication Data**

Main entry under title:
Small hydro power resource in the provincial system

(Energy conservation and technology projects, ISSN 0823-4973)

Includes bibliographical references.
Contents: Technology and resource assessment -- Economic and financial assessment / Sigma Engineering Ltd., Robinson Consulting & Associates Ltd.
"SEL 5242"; "SEL 5276"
ISBN 0-7718-8415-X (set). -- ISBN 0-7718-8416-8 (v. 1). -- ISBN 0-7718-8417-6 (v. 2)

1. Hydroelectric power plants - British Columbia. 2. Electric power production - British Columbia. 3. Hydroel[illegible]ic power plants - Economic aspects - British Columbia. 4. Electric power production - Economic aspects - British Columbia. I. Sigma Engineering Ltd. II. British Columbia. Energy Resources Branch. Conservation and Technology Division. III. Robinson Consulting and Associates. IV. Series.

TK1427.B7S62 1984 333.79'32'09711 C84-092074-1

# ADVICE AND DISCLAIMER

This report was funded and published by the Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia, as a public service. Although it is believed to be accurate, the Ministry does not warrant the accuracy of its contents. The Ministry does not guarantee or assume any liability for the effectiveness or the economic benefits of the processes or data described in the report.

Readers are advised that rights to the use of processes or data referred to may be privately held.

Note: As some of the maps have been reduced for this reproduction, map scales are not necessarily accurate.

First printing, February 1984

PROVINCE OF BRITISH COLUMBIA

MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

# SMALL HYDRO POWER RESOURCE
# IN THE PROVINCIAL SYSTEM

## TECHNOLOGY AND RESOURCE ASSESSMENT

SEL 5242
JULY 1983

SIGMA ENGINEERING LTD

# FOREWORD

The study of the small hydro power resource in British Columbia resulted from a growing interest in the subject, both from the viewpoint of the private investor and of the Provincial Government who are responsible for managing the resource. Its purpose is to serve as both a development manual and a catalogue of the entire resource, as it pertains to the integrated or remote grid systems of the provincial utilities.

It should be noted that the baseline date for the study is the spring of 1982, when most of the research was done. Since then until the final completion of the report in late 1983, a number of report revisions have occurred, but the baseline data have remained the same.

During the past 1½ years there have been changes in power rates, public utility policies, government policy and interest rates. These factors play a significant role in determining the feasibility of any power development and they must be verified during the course of a small hydro power study.

The scope of this report can be summarized as follows:

- to the provincial government, it provides both a magnitude and distribution of the resource with some ideas for shaping public policy toward future small hydro power development;
- to the investor, it provides guidelines for developing small hydro power sites from a technical and regulatory viewpoint;
- to the individual with a requirement for his own power supply, it provides step by step guidelines to establish preliminary designs and costs of a small hydro power system.

An investigation of the site conditions, which may comprise the largest variable in small hydro power development, was beyond the scope of this report. It cannot be overemphasized that any prospective site must be investigated on the ground at an early stage. With this in mind this report can provide a starting point for the further development of the resource in an organized and economical manner.

# CONTENTS

Page No

1. INTRODUCTION

1.1 Background 1 - 1
1.2 Terms of Reference 1 - 2

2. TECHNOLOGY ASSESSMENT

2.1 Background 2 - 1
2.2 Hydro Power System Description 2 - 3
2.3 Turbines 2 - 4
2.4 Generators 2 - 11
2.5 Governors 2 - 13
2.6 Protective Devices 2 - 15
2.7 Penstocks 2 - 18
2.8 Dams and Intakes 2 - 23
2.9 Powerhouse Features 2 - 25

3. RESOURCE ASSESSMENT

3.1 Background 3 - 1
3.2 Project Area 3 - 2
3.3 Existing Sites 3 - 3
3.4 Hydrology 3 - 4
3.5 Map Studies 3 - 5
3.6 Design Standards 3 - 7
3.7 Project Analysis 3 - 8

Page No

4. PROJECT FEASIBILITY

4.1 Interconnection Policies 4 - 1
4.2 Wheeling Power 4 - 4
4.3 Cost Estimates 4 - 5
4.4 Revenue Estimates 4 - 6
4.5 Financial Considerations 4 - 7

5. MAGNITUDE OF THE SMALL HYDRO POWER RESOURCE

5.1 Potential Small Hydro Power Sites 5 - 1
5.2 Water Licences Held at Undeveloped Small Hydro Power Sites 5 - 2
5.3 Existing Small Hydro Power Installations 5 - 4

6. SUMMARY AND RECOMMENDATIONS

7. REFERENCES

APPENDICES/MAPS

1. Resource Maps and Tables

2. Examples of Site Evaluation Procedures

3. Manufacturers Information, Specifications, and System Diagrams

4. Implementation of a Small Hydro Power Project

5. Hydrology Information

# 1. INTRODUCTION

## 1.1 BACKGROUND

The first small hydro power schemes in British Columbia were constructed in the late 1800s. The number of operating plants increased for a while, but then began to decline as more economical sources of energy became available. The alternative sources were the expanding provincial grid supplying inexpensive power from major hydro power developments, and diesel generators serving settlements too remote to be connected into the grid.

In recent years however, the prospect for the development of small hydro power sites has become much more promising. In the case of systems now supplied by diesel generation, this is due to the large increase in the cost of diesel fuel since the energy crisis of 1974. In the case of the provincial grid, the cost of energy provided by the new large hydro power sites is beginning to approach or exceed the cost of energy from prime, small hydro sites.

There are a number of reasons for promoting small hydro power as a renewable energy resource. Individual developments are small and therefore benefits from construction are likely to be widely dispersed, and the disruptions associated with very large projects are avoided. Although small hydro power is capital intensive, most of the expenditure is for design, construction, materials, and equipment which are readily available in Canada. Operating costs of a small hydro plant are low, so the energy produced is relatively inflation proof. Finally, British Columbia is especially fortunate with its steep topography to develop high head (high water pressure) small hydro power projects.

Not only would small hydro power projects serve as useful energy sources, but they also provide an opportunity to develop the technology and make British Columbia a world leader in this small but significant field, leading to the possibility of exporting equipment and engineering services.

In order to assess the small hydro power resource in the provincial system, two complementary studies were commissioned by the Ministry of Energy, Mines and Petroleum Resources, and completed in July 1983.

In this primary study the status of the technology of small hydro power was first reviewed. Then an inventory was developed covering the hydro power sites in British Columbia with an installed capacity of less than 20 MW, which are in suitable locations for interconnection with the B C Hydro and the West Kootenay Power and Light systems, or with local distribution lines. However the numerous logging camps, fishing camps, mines, resorts, Indian villages and private residences which generate their own power were not catalogued during this study. These remote sites, some of which are already served by a small hydro power plant, were covered in a previous report, **Micro Hydro**, (Crippen, 1980).

Preliminary estimates were made of the available installed capacity and the relative cost of energy at individual sites, but site investigations were not made.

The report also deals with the technical and legal aspects of connecting a small hydro power scheme to a larger electrical system.

The companion volume to this report builds on the cost data developed here in order to determine the economic feasibility and the financial viability of the resource, and is entitled, **Small Hydro Power Resource in the Provincial System, Economic and Financial Assessment**.

## 1.2 TERMS OF REFERENCE

In February 1982, SIGMA Engineering Ltd were authorized by the Ministry of Energy, Mines and Petroleum Resources to undertake a study of the small hydro power potential of British Columbia and a review of the technology.

The detailed scope of work is as follows:

## PHASE 1 - TECHNOLOGY UPDATE

### Small Hydro Power Equipment

- provide typical equipment specifications on types of systems likely to be used in British Columbia. Components will include civil works, penstocks, turbines, generators, controls, protection equipment and transmission equipment;

- provide approximate cost information on the above works to assist in evaluating project proposals;

- provide examples of equipment configurations, and the benefits of certain arrangements.

### Interconnection Policy

- collect information from utilities to assess the magnitude of legal and technical requirements which will be faced by small hydro power installations connected to the grid.

## PHASE 2 - RESOURCE ASSESSMENT

### Hydrology

- provide a method of design flow estimation based on rainfall statistics, streamflow measurement and mapping.

### Power Potential

- estimate the potential for the connection of small hydro power schemes to the provincial electric grid, using actual basins as examples;

- estimate the potential for the connection of small hydro power schemes to isolated systems, particularly B C Hydro diesel generation systems.

# 2. TECHNOLOGY ASSESSMENT

## 2.1 BACKGROUND

The use of falling water as an energy source dates back to the earliest waterwheels, but the modern era in hydro power development began with the invention of water turbines in the 19th century. These early turbines were used in mills for driving machinery, but this use was limited by the difficulty in transmitting and distributing power mechanically. With the further development of electrical technology, it became possible to generate and transmit power for both commercial and domestic purposes. As the use of electricity became widespread, electrical transmission grids developed, and larger and larger electrical generating stations were constructed to exploit economies of scale. In the case of hydro power systems, the development of high voltage transmission technology allowed large remote sites to be developed and tied into power grids.

Since the invention of the turbine, water power technology has been developing continuously, but as with other technologies the main conceptual breakthroughs came in the early stages with later refinements in design, materials and manufacturing techniques. Because of the trend towards larger schemes, most of the development work became concentrated on large turbine/generator units, and since the 1940s there have been relatively few small units installed, and indeed many early small power plants were allowed to fall into disuse as it became more economical to buy power from the grid than to maintain the older, smaller systems in operation. Thus small hydro power technology stagnated with few new developments and many of the manufacturers went out of business. At the same time some of the side effects of large projects began to be apparent, and pressure to preserve the environment led to increasingly complex licensing requirements. The same procedures tended to be applied to small and medium sized projects which further reduced the incentive to develop small and medium sized hydro power plants.

The situation began to change in 1974 when oil prices increased suddenly thus increasing the cost of electrical energy generated in oil fired thermal power plants. This led to an immediate search for alternatives, including a second look at the neglected small hydro power resource. Although an attractive alternative, with many potential advantages, small hydro power was still entangled in the same regulatory maze as large hydro power and this offset the advantages.

A significant breakthrough for small hydro power development in the United States came when the Federal Energy Regulatory Commission (FERC) adopted the Public Utility Regulatory Policies Act of 1978 (PURPA). This regulation defined small hydro power systems (less than 80 MW), established regulations which would permit their operation and obligated electric distribution utilities to buy the generated energy and capacity at rates equivalent to their avoided cost (i.e. the cost of the more expensive energy the utility would normally have to purchase to supplement its less expensive base load power supplies). The Department of Energy funded comprehensive studies on small hydro power assessment and offered loans and grants to help establish small hydro power facilities. Direct benefits of the legislation have been felt in British Columbia, where several local turbine manufacturers have received orders for turbines for the United States. The indirect benefits are that legal and technical precedents have been established and there is now a competitive market for turbine equipment.

The growth of electrical consumption and distribution in British Columbia has followed a similar pattern to that outlined above. Since BC Hydro system costs are virtually independent of thermal generation and only a small portion of the system is powered by diesel, most of the consumers of electrical energy in British Columbia have been insulated from the dramatic price increases faced by some others. In fact, the average price of electricity in real terms dipped between 1964 and 1974, and from then until 1980 it closely followed the trend of the consumer price index. Despite the growth in the transmission system, there are still a large number of isolated communities whose distance and intervening topography separate them from the provincial electric grid. System operators in these isolated areas, including BC Hydro and private producers, face the full impact of price increases in fuel supplies, and they stand to gain the most from small hydro power systems. Under the right circumstances small hydro power systems can also be economic in areas already served by the electric grid. However, procedures for licensing and buying the power from small hydro power developments have not yet been set up and streamlined in British Columbia.

The result of the favourable economic climate for small hydro power has been a large increase in business for established suppliers of equipment and the formation of many new firms to market and sell the products. Until recently the concentration has been on larger projects, leaving many small turbine designs based on old technology, with few changes over the years. On the other hand, the electrics have improved considerably with the development of compact, more efficient generators, brushless exciters, electronic voltage regulators and more recently the adaptation of microprocessors to the control and data logging of small hydro power plants. These applications allow improved and less expensive speed regulation, control and monitoring systems to be used with small systems. These new innovations are discussed along with the existing technology in the following sections.

## 2.2 HYDRO POWER SYSTEM DESCRIPTION

A hydro power system, regardless of size, requires several components to convert the potential energy of the water into electrical energy and safely transmit it to the power user. Water must be admitted through an intake (with or without a dam) and carried in a pipe (a penstock) to the powerhouse. The pressure of the flowing water is converted to mechanical energy by the turbine, which drives the generator. The generator converts the mechanical energy of rotation into electrical energy at a relatively low voltage. The energy is then fed through a transformer to increase the voltage to that of the transmission line which carries the energy to the customer, where transformers are again used to reduce the voltage to an acceptable level for consumer use.

An automatic turbine governor is required to control generator speed so that a constant output frequency (usually 60 Hz) is maintained. Typically, there are numerous fault detectors which are set to shut down the turbine if problems with the equipment or unstable conditions develop. Protective devices are also provided to prevent harmful electrical conditions in the grid line (if it is so connected) from damaging the generator. In general the complexity of the protection system increases with the output of the plant and the transmission voltage.

A diagram of a typical system is shown in Appendix 3, Figure 3.1. The components at each site will be different, but the overall configuration would be similar.

## 2.3 TURBINES

The first turbines were water wheels, which depended on the weight of falling water in buckets to turn the wheel and drive machinery. These systems have been used for centuries and were used in British Columbia in the early days of the mining industry.

It was not until the mid 1800s that the first pressure turbines were developed. These too were water wheels, but the driving force was the action of a pressurized jet of water. A number of companies became involved in the production of these systems as any machine shop with a forge could fabricate the product. A few of these companies which started out with a well manufactured product have survived the many ups and downs of the industry for over 100 years.

Once the use of electricity became widespread, the need for hydraulic turbines increased. Accordingly the developments in the hydraulic machinery field were rapid and more powerful machines were evolved. Applications for the water wheel or Pelton wheel became limited to high head situations where large power outputs could be provided. Medium head reaction turbines known as Francis turbines were developed, as well as low head propeller turbines. The low head propeller turbine with variable pitch blades for higher efficiency at partial flows became known as the Kaplan turbine.

The most recent developments in turbines include the Crossflow turbine which was invented in the early 1900s and the Turgo Impulse wheel invented in 1920.

The Crossflow turbine uses a vaned wheel on a horizontal shaft. It is used in a variety of applications, sometimes replacing an impulse (Pelton) machine and sometimes a reaction (Francis) type. Its advantages are that it produces power at a reasonable efficiency under conditions of varying head and flow. The Turgo Impulse wheel was designed to suit applications in between the optimum ranges of the impulse and reaction turbines. It is classed as an impulse turbine, but because of its shape, it has a higher power output for the same runner diameter and within its range it is usually more economical than the impulse or reaction turbines with similar outputs. The range of peak efficiences for hydraulic turbines is from about 80 to 90 percent or higher. The characteristics of the various turbines commonly used for small hydro power projects in British Columbia are shown in Table 2.1.

Since the early part of the century the basic turbine designs have changed little and most of the improvements have been in manufacturing techniques and materials. The original cast iron runners have been replaced with bronze and stainless steel runners, which are more corrosion and cavitation resistant.

Cavitation can occur when the water velocity is high and the pressure is low, such as occurs at the discharge end of a reaction turbine. Because of the low pressure the water literally boils and produces vapour filled cavities which can then collapse suddenly when carried to a region of locally higher pressure. If the collapse occurs on the equipment surface severe erosion and damage can result. The cavitation problem continues to affect even newer turbines, since there has been a tendency to produce smaller, faster machines which are less expensive. The faster a machine rotates, the more likely it is to suffer cavitation damage particularly to the turbine runner. Most manufacturers are careful to specify the head, elevation above sea level, water temperature and elevation above or below tailwater for which their machine is designed to operate without cavitation. It is important to minimize the potential for cavitation by carefully following the manufacturer's recommendations. Faster turbine speeds also increase the wear on bearings, and additional cooling and lubrication systems may be required.

A persistent problem with turbine manufacture is that virtually every machine is unique. There are infinite combinations of flow and head, hence an almost infinite number of designs. Each time an order is received, the turbine must be designed to suit the site parameters and, in the case of large turbines, hydraulic models are usually tested before actual fabrication begins. Manufacturers that have been in business for a long time will usually save their old patterns, but even these may require modification each time they are reproduced. The result is that delivery of most small turbines takes at least one year. Very small turbines (for household use) can sometimes be purchased off the shelf while delivery of the larger turbines may take even longer than one year.

An idea that is finding increasing acceptance for small hydro power projects, particularly the very small (less than 50 kW) range is the use of pumps as turbines. By reversing the flow through a pump it can be made to run at a similar efficiency as its pump efficiency and at a higher head and flow, meaning higher output. There are numerous manufacturers of pumps, so selection can be wide, prices competitive and delivery times short. The selection process should include obtaining design curves from manufacturers (assuming that they have tested their pumps as turbines), checking the durability of the pump as a turbine, and coordinating the connection of the pump to the generator.

The improved market for hydraulic turbines, especially in the United States in the low head range, has resulted in several manufacturers producing standardized packaged units. This has been the biggest advance in small hydro turbine technology in recent years. Unfortunately it has largely been confined to low head units, while in British Columbia the most common requirement is for medium and high head units. Standardization has helped shorten the time from the conceptual to the commissioning stage and reduce the cost. The greatest benefit has occurred to the small hydro power sites where existing civil works are in place and upgrading is being considered. The main types of packaged units, all of which are used on low heads, are summarized in Table 2.2.

## TABLE 2.1
## TURBINE CHARACTERISTICS

Sheet 1 of 2

| Type | Application and Advantages | Disadvantages |
|---|---|---|
| **Pelton**<br>Head: to 1000 m<br>Output: to 20,000 kW | - High heads, low specific speed.<br>- Good efficiency over a wide range of flows.<br>- High RPM reduces generator cost.<br>- Few moving parts.<br>- Water from the turbine discharges freely and has only to be channeled away. This simplifies the civil works. | - Some loss in head because turbine discharge must be above maximum tailwater level. |
| **Francis**<br>Head: to 300 m<br>Output: to 500,000 kW | - Medium heads<br>- High efficiency at rated output<br>- Moderate Specific Speed<br>- High capacity | - Efficiency falls off at part load.<br>- Tailwater level must be controlled to avoid cavitation<br>- Many moving parts |
| **Crossflow**<br>Head: to 200 m<br>Output: to 2500 kW | - Medium to high heads<br>- Efficiency nearly constant over wide range of flows<br>- Low specific speed<br>- Few moving parts<br>- Water from turbine discharges freely so no need to control tailwater level | - Lower overall efficiency<br>- Must use fine debris screens<br>- Can be noisy |
| **Turgo**<br>Head: to 250 m<br>Output: to 4500 kW | - Low to moderate Specific Speed<br>- Covers a range where Francis and Pelton turbines are at the limit of their application<br>- Few moving parts<br>- Water discharges freely so no need to control tailwater level | - Some loss in head because turbine discharge must be above tailwater |

## TABLE 2.1
## TURBINE CHARACTERISTICS

Sheet 2 of 2

| Type | Application and Advantages | Disadvantages |
|---|---|---|
| **Propeller** | - High Specific Speed | - Physically large |
| Head: to 30 m<br>Output: to 50,000 kW | - Low Head | - Efficiency is good only near rated output |
| | | - Sensitive to tailwater levels |
| **Kaplan** | - High Specific Speed | - Complicated mechanically |
| | - Low Head | - Physically large |
| Head: to 30 m<br>Output: to 50,000 kW | - High efficiency over a wide range | - Sensitive to tailwater levels |
| **Reversible Pump** | - Suited to very small installations | - Slightly lower efficiency |
| Head: Varies<br>Output: Varies | - Can be purchased "off the shelf" | - Design coordination required to match pump to generator |
| | - Much less expensive than a turbine, for the same output | - Is really only suited to continuous operation at full load as efficiency falls off rapidly at part load. |
| | - Good selection, many manufacturers | |
| | - Suited to steady load | |

**Definitions**

**Head:** The effective height of water above the turbine.
Gross head is the intake level minus tailwater level.
Net head is gross head minus energy losses in the penstock.

**Specific Speed:** A means [illegible] classifying turbines as to type.
Turbines of identical geometric shape but of different size will have the same specific speed.

$$\text{Specific Speed (English units)} = \frac{\text{Operating Speed RPM} \times \text{Horsepower}^{\frac{1}{2}}}{\text{Head}^{1.25}}$$

The pricing of turbine units is not straightforward due to the large number of variables in turbine design, and at the planning stage reliance is placed on experience curves based on what delivered units have cost in the past. The usual inflation factors can then be applied to estimate a current price. Generally arriving at a final price is much more complicated. The turbine business is international in scope, so exchange rates, import duties, delivery time, interest rates, language and shipping problems must all be considered in respect of purchases outside Canada. Federal sales tax will also be applied at the port of entry, but this can be refunded if the proper procedures are followed. Even a portion of the duty can be refunded if it can be proven that no Canadian firm could fill the order. The bidding climate at the time of ordering can also affect the cost of the turbine. With some manufacturers overworked, certain enquiries may not receive favourable consideration unless the job fits the particular production schedule of the company. It is important to direct the enquiry for information and the tender request to suppliers that are both capable and willing to perform the work. In Appendix 3, Page (i) some of the manufacturers of small hydro turbines are listed, together with some typical specifications, while cost curves are presented in Appendix 2, Figure 2.3.

## TABLE 2.2

## PACKAGE TURBINE SETS

| Type | Application and Advantages | Disadvantages |
|---|---|---|
| **Bulb** | - Low head, direct coupled generator to propeller turbine enclosed in waterproof chamber suspended in water passages<br>- Riser pipes connect to powerhouse floor level for servicing | - Possible leakage problems<br>- Complicated civil works for water passages |
| **Tubo**<br>(Allis Chalmers) | - Horizontal shaft propeller turbine with curved water passages made of steel<br>- Generator and controls easily accessible in powerhouse | - Long shaft<br>- Bearing design and sealing are critical |
| **Straflow or Rim Generator** | - The generator stator is embedded in the concrete water passage, with the rotor attached to the turbine blades<br>- Compact | - Potential sealing problems with electrical components<br>- Complicated design |
| **Mini Hydel**<br>(Barber Turbines) | - Prefabricated factory built unit consisting of a Francis or propeller turbine, generator, gear box, governor and controls built for low heads and power outputs to 1000 kW<br>- Provides for rapid installation of the principal components, often with a minimum of related civil works. | |

## 2.4 GENERATORS

The technology of generators is well established and there are many manufacturers in the business. However, there tends to be a size distinction, with one group of manufacturers supplying the lower speed range, physically large machines, while another group specializes in the smaller high speed machines. The large generators are generally custom built, one of a kind designs. The more common high speed generators are standardized to some extent for application to the diesel generator and small hydro market. They generally operate at 1200 - 900 RPM and are geared to suit turbine speed. Large hydro power projects and those operating in isolation invariably use synchronous generators while small hydro plants operating in parallel with the utility or an existing synchronous generator may use an induction or asynchronous generator. Their merits are discussed below and compared in Table 2.3.

### Synchronous Generators

Synchronous generators are available in a wide range of sizes and can be used either in parallel with an existing system or in a remote installation. The synchronous machine has its own DC excitation system and voltage regulator, which provides for control of the output voltage over a range of loads.

Within its rating the synchronous generator can operate at a leading power factor and provide for the demands of lagging power factor loads such as induction motors and fluorescent lights. These loads require a higher kV.A (kilovolt ampere) capability even though the rated power (kilowatts) may be the same as a resistive load with a power factor of unity.

In the case of an isolated system the turbine governor is required to control generator speed so that a relatively constant output frequency, usually 60 Hz, is maintained at all loads within the capability of the turbine and generator. In a parallel system it is necessary to control and match the generator no-load frequency, voltage and phasing so that the generator can be synchronized with the system. The degree of frequency and voltage control (regulation) required is a function of the type of electrical loads being served. Lighting loads require reasonable voltage control while motor loads require relatively close control of

## TABLE 2.3

## GENERATORS

| Type | Application and Advantages | Disadvantages |
|---|---|---|
| **Synchronous** | - Isolated systems | - Multiple units must all be synchronized |
| | - Large systems | |
| **Asynchronous or Induction** | - Less expensive than synchronous generator in smaller sizes | - Must be feeding into a much larger power system with synchronous machines |
| | - Ideally suited to small systems tied to a power grid | - Requires separate overspeed control |
| | - Does not require a governor as speed is controlled by the main grid system | - Size is limited |
| | - Rugged construction | - Lagging power factor may need to be compensated |

both frequency and voltage to enable the motors to perform at design speed and load.

### Induction Generators

Induction or "asynchronous" generators obtain their excitation from the power system they are connected to and as such can only be used in parallel with synchronous machines. They are similar in construction to an induction motor and more rugged than a synchronous machine and generally less expensive. The governor system may be simplified to a load control system since the generator will match its speed with that of the controlling system frequency.

There are a few disadvantages to the induction generator. The first, as previously mentioned, is that it cannot operate in an isolated system but must be part of a larger system which provides stability, and voltage and frequency control. The second is due to the fact that generation is brought about by the turbine attempting to speed up the induction generator above system synchronous speed and thereby feeding power into the system. In this situation, when system load is suddenly lost, the turbine and generator immediately begin to speed up and a sensitive and reliable overspeed trip and a stored energy type shutdown device is required to protect the rotating machines from damage. Larger induction generators may draw excessive inrush current and cause considerable voltage drop when starting as a motor. In addition, power is fed into the network at a lagging power factor which requires that var support comes from the system, something which may not be acceptable to the utility without further consideration of power factor correction. Examples of generator suppliers and related information are given in Appendix 3.

## 2.5 GOVERNORS

The governor is the most complicated and sensitive device in the hydro turbine system. It is designed to sense speed variations, which are indicative of load changes, and adjust the flow of water to the turbine to maintain a 60 Hz frequency.

Originally, many turbine manufacturers made their own governors. However, this field is now dominated by the Woodward Governor Company of Rockford, Illinois. A few foreign turbine manufacturers make their own governors and more recently there have been electronic governors developed for small systems.

The most common type of governor is the gateshaft governor with accumulator. It operates with an electric motor drive operating at the same frequency as the generator. When the generator frequency changes due to a load change, the speed of the drive motor changes and mechanical linkages are activated which change the flow of pressurized oil in the servo system. The servomotor (a hydraulic piston) acts to open or close the turbine gates and hence correct the speed of the turbine. This form of system has been available for many years, is very reliable, and comes in different sizes for different turbine loads. A disadvantage is that it is available only in larger sizes so that very small capacity turbines are faced with a relatively high fixed cost.

The newer electronic load dumping governors are designed to economically govern the smallest hydro plants. The system features a load bank of resistors controlled by an electronic sensor. The sensors control the load into the resistors such that the total load on the generator is constant. When the power requirements of the load decrease, the power to the resistor banks increases by the same amount. This system is only limited by the size of the resistor banks and the cost of dissipating a potentially large concentration of heat. There is an advantage in that the constant load reduces the need for surge tanks or pressure relief facilities. The turbine will operate at full flow until there is a shut down, at which time the load is picked up by the resistor banks and the turbine will be shut down slowly. The governor can also be tied in to intake water level sensors to regulate power outputs when flows are low, or conserve water if required.

The various types of governors are described in Table 2-4 and specifications are covered in Figure 3.3.

## TABLE 2.4

## GOVERNORS

| Type | Application and Advantages | Disadvantages |
|---|---|---|
| **Gateshaft** | - Virtually all sizes of small hydro turbines | - The cost of the minimum size can be a high proportion of the cost of a small installation |
| **Electronic** | - Suited to small installations<br>- Inexpensive<br>- The size of the governor varies with the size of the turbine output<br>- Makes possible a better load factor and fuel substitution at remote sites | - Excess energy turned into heat must be dissipated<br>- Requires full flow until the unit is shut down. |

## 2.6 PROTECTIVE DEVICES

Hydro power systems have always used protective devices to some extent, but advances in electronics and customer requirements for more sensitive operation have tended to increase the level of protection provided. There are two categories of protection systems that may be required, hydro-mechanical protection for the plant and electrical protection for the power system.

### Hydro-mechanical Protection

Protection of the physical operating features of the plant is important to prevent the turbine from being damaged if a harmful condition arises. The basic system involves a monitoring probe, which measures a critical parameter, linked to a relay which in turn is linked to a warning or shut down system. The parameters monitored can include bearing temperature, turbine speed, vibration, gate position, water temperature, head pond levels, trash rack conditions, oil flow, accumulator pressure or any other plant system features whose malfunction can lead to trouble.

The penstock can also be protected from water hamnmer conditions arising from rapid turbine shutdown through the use of jet deflectors on the turbine, surge towers, pressure relief valves or bypass valves.

## Electrical Protection

The subject of electrical protection is one of the more difficult to define in the small hydro power system, as well as involving some of the most complicated details. Details usually are entirely site specific. In an interconnected system, there must be protection provided for the generator against conditions arising in the utility, the generator and powerplant itself. The utility must be protected against conditions arising in the powerplant.

The utility must be protected to ensure that its customers are not subjected to power fluctuations from any of the generators tied into the system. The types of conditions protected against vary with the output of the generator, the classification of the receiving transmission line, and the particular utility requirements.

The generator must be protected against conditions arising from the utility. For example, lightning or wind can cause transmission line problems which must be prevented from affecting the small hydro generator. Typically a breaker would be provided to put the small hydro generator off line if a problem arose in the larger utility system.

The powerhouse itself can also be subject to numerous problems in addition to the mechanical aspects already mentioned. Details of the protection systems would depend on the type of generator, governor, transformers, breakers and relays already in use.

The final authority on the types of protective devices used will be the utility which is allowing the customer owned generator to connect. Only the utility can determine the impact of the proposed generating facility on its system and it must take reasonable precautions to ensure that its interests are protected, without being unreasonable to the prospective developer of a small hydro power scheme. Basic details must be outlined in the utility's interconnection policy, but these can only serve as a rough guide, which cannot cover all of the possibilities. Thus the utility will play an important role in the process, by outlining the basic requirements and reviewing the proposals.

In a typical project connected to a low voltage distribution line, the systems below might be incorporated. It is important that all the systems be designed together to ensure that they are coordinated with each other:

**To protect the generator from the utility:**

- lightning arrestors, fuses, load breaks

**To protect the utility from the generator:**

- under and over voltage protection
- under and over frequency protection

**To protect the generator and turbine mechanically**

- overspeed control
- bearing temperature control
- vibration control

An example of a protection system used on a small hydro power project is shown in Appendix 3, Figure 3.4.

## 2.7 PENSTOCKS

Hydro power systems originally had few choices for penstock construction, with the primary materials being cast iron, rivetted steel and wood stave pipes.

In modern small hydro power systems there are numerous choices for the penstock material, and no pipe type is clearly the best choice for every situation. Availability, pressure rating, friction loss, site conditions, ease of installation and price must all be considered before a final pipe selection is made. Of these, an assessment of the site conditions is the most important consideration to determine the suitability of a given pipe for the project.

Many of the newer developments in pipe technology were created in the water supply and drainage industry since these applications are more numerous than hydro power. These pipes are generally available only in smaller sizes, but usually within the size ranges required for a small hydro power scheme.

The different types of penstocks are compared in Table 2.5; typical diameter and pressure ranges are shown in Appendix 3, Figure 3.5.2 and typical costs and diameters for 700 kPa/100 psi are shown in Figure 3.5.1. The following types of pipe and installation techniques are available for use in small hydro power systems.

### Wood Stave

Wood stave pipe is a versatile penstock material in that the pieces are easily transported, curves can be built in, and higher pressures can be contained by using more steel hoops. It is available in a wide range of sizes up to 6 metres in diameter. It has some disadvantages in that it is labour intensive to construct and has a life span of about 40 years, depending on the environment. The individual staves are staggered when placed and ends are butt jointed together using metal butt connectors or finger joints machined in the wood. The pipe must also be supported at frequent intervals if it is not buried.

### Steel

Steel pipe can be used in all size ranges and its principal benefits are its strength and versatility. It can be installed using standard welding techniques and can be unsupported over long spans. Flange joints can also be used. It also has some disadvantages especially when exposed. It must be protected from corrosion and the support system must absorb the stresses and movement resulting from thermal expansion. The weight of the pipe means that even in small sizes it must be put in place by machine methods. It has a life span of more than 60 years with suitable surface protection and maintenance.

### Concrete Cylinder Pipe

This form of pipe combines the tensile strength of steel with the compressive strength of concrete. It is factory made in standard diameters and is fitted together using a bell and spigot joint. Because of the joint system and relatively heavy weight it is preferable to bury the pipe. The pipe can be installed relatively easily if heavy lifting equipment is available, but installation is more difficult over rough ground. Concrete pipe has a long lifespan.

### Ductile Iron Pipe

Ductile iron pipe would be the same type as used in waterworks. It is available in diameters up to 0.6 metres and is heavy and durable. It is bell and spigot jointed, hence burial is the preferred installation method. Pressure ratings are up to 2450 kPa/350 psi and the lifespan is in the order of 50 years.

### PVC Pipe

PVC pipe has many of the properties of ductile iron pipe except that it is not subject to corrosion and is lighter in weight. Pressure ratings are typically to 1400 kPa/200 psi and the joints are bell and spigot. It should only be considered

## TABLE 2.5

## PENSTOCKS

**Sheet 1 of 2**

| Type | Application and Advantages | Disadvantages |
|---|---|---|
| **Wood Stave** | - Will handle corrosive waters<br>- Flexible, can take short spans<br>- Can be assembled without machines<br>- Does not require large anchors to restrain expansion | - Leakage is common<br>- Expensive to purchase pipe<br>- Lifespan is less than other types of pipe |
| **Steel** | - Can be custom welded<br>- High pressure rating<br>- Can be used on long spans | - Must be protected from corrosion to ensure long life<br>- Expensive to install<br>- Needs expansion joints to handle thermal expansion |
| **Concrete Cylinder** | - Installed with slip joints<br>- Not subject to corrosion | - Heavy<br>- Must be buried |
| **Ductile Iron** | - Slip joints, easy to install<br>- Relatively inexpensive | - Can be corroded<br>- Must be buried |
| **PVC** | - Light, easy to install<br>- Smooth inner surface low friction | - Must be buried (sensitive to ultraviolet light) |

## TABLE 2.5

## PENSTOCKS

Sheet 2 of 2

| Type | Application and Advantages | Disadvantages |
|---|---|---|
| Polyethylene | - Available in many sizes and pressure ranges | - Must be restrained from excess thermal movement |
| | - Able to tolerate pressure transients | |
| | - Easily curved | - Expensive |
| | - Can be buried or above ground | |
| | - Light weight | |
| | - Can be pre-assembled and dropped or dragged into place | |
| | - Smooth, not subject to corrosion | |
| | - Not damaged by freezing | |
| Fibreglass Pipe | - Pipe sections can be custom made or manufactured to standard sizes | - Should be buried to 50% of the diameter or more |
| | - Light weight, easily placed | - Expensive |
| | - Smooth, not subject to corrosion | |

for buried installations because it is sensitive to ultraviolet light, but the lifespan could approach 100 years. With proper protection from uitra violet light, solvent welded couplings (glue joints) could be considered for above ground installations.

### Polyethylene Pipe

Polyethylene pipe is finding increased uses in small hydro power installations. It is light, flexible, suited for above ground installation and easy to install. It is available in pressure ratings to 1400 kPa/200 psi. Polyethylene pipe is especially economical where it is used in the low pressure part of the penstock. It is available in diameters up to 1.5 m, although the full pressure rating is only carried up to the 0.4 m size. It can be jointed using thermal butt fusion or flanges, and the lifespan would approach 100 years.

### Fiberglass Wrapped Pipe

Fiberglass is a newer pipe material. It can be factory or field manufactured to diameters of 6 m and is not subject to corrosion. It is also easily modified for customized conditions and is light in weight. It is best suited for buried situations, to pressures of 1050 kPa/150 psi. Manufactured sections, which include fibreglass wrapped PVC, can be curved gradually in a trench and are sometimes available to 2450 kPa/350 psi rating. Joints are most often bell and spigot, but flanges can be supplied.

### Penstock Supports

There are several types of penstock support available which are used for different conditions of topography and pipe material. The simplest and best support is the ground, which can be used for all pipe types (preferably with full burial). Ground support provides uniform pipe support, restrains pipe movement and protects the pipe from external damage.

When the pentock must be placed on or above the ground the support system must be carefully designed. Pipe material, water pressure, span and support size must all be considered. In general, supports for above ground pipes are only practical where the pipe is continuously jointed or where frequent support intervals are tolerable. Pipes most frequently using support systems are steel, polyethylene, wood stave and glued PVC. Some support types are listed below:

- concrete pedestals for small diameter steel or polyethylene;
- steel pedestals with half steel cylinder for steel pipe;
- wood frame supports with saddles for polyethylene or PVC;
- wood or steel cradles for wood pipe.

As systems get smaller, the types of support can become more innovative and less expensive as long as the owner of the project is prepared to spend time on repair and adjustment.

Penstock supports are used mainly for straight sections of pipe. Where sharp bends are involved the pipe must be restrained from thrust forces by an anchor block. Hydraulic forces and thermal expansion forces (especially with steel pipe) are concentrated at these bends, and restraint in the form of rock anchors or mass concrete must be provided. The design of anchors can only be optimized by considering all the site conditions.

## 2.8 DAMS AND INTAKES

Every small hydro power project must have a means of creating a head of water above the turbine, to allow the potential energy in the water to be utilized. This can be done with a dam or a gathering intake, depending on the topography. Other purposes of the dam or intake include water storage and providing for inlet conditions.

### Dams

Dams can be constructed in all heights and configurations. Simple dams, sometimes made of timber cribbing, can be used for low heads and very small installations. However, a properly constructed earthfill or concrete structure is preferable to avoid long term maintenance and replacement costs.

Most small hydro power projects, in order to be economic, cannot depend on a dam for all of the head, so the water is carried to a lower elevation in a penstock. There will probably be a few ideal situations where a dam alone can create enough head with sufficient water for an economical project, but these are rare.

## Intakes

The more common type of system for the high head power sites prevalent in British Columbia is the run of river intake. This is a relatively simple structure located within a stream. There is only a small amount of water impounded, which will not smooth out daily flow variations.

The intake should be designed to allow bedload from the stream to pass by the structure while water is admitted to the penstock. A shallow, low flow diversion weir is often provided so the inlet is deep enough so that ice problems and vortices are not created. The structure itself must be durable and securely anchored to the ground. There must be a shut off valve followed by an air vent near the inlet. Trash racks and/or screens are located on the outside of the intake structure to prevent bedload or debris from entering the penstock. (Sometimes heating is added to trash racks to prevent ice build-up). Settling tanks or ponds are often provided to remove finer sediments.

In the run of river intake it is important to allow for future maintenance if bedload accumulations are possible. There must be a means of cleaning out sediment and of servicing the screens and valves of the intake. Relatively easy access to the intake must also be provided for the operation of the inlet valve, and there should be a water level gauge which can be read to determine stream flows.

Another form of intake is the drainage gallery. This system avoids the trash rack because water is admitted through pervious soil to a sump, from where the penstock originates. The system requires a large diameter infiltration pipe and is very sensitive to soil permeabilities. The advantages are that the drainage gallery intake can be located away from the watercourse and thus protected from ice and debris. The disadvantages are that a large collection area may be required and that the soil may become clogged with fine sediments, especially if a permeable filter bed is installed that is much cleaner than the natural soils of the stream bed. It is usually impossible to clear a clogged intake by applying back pressure to the penstock.

All types of intakes can have water level control and sensing devices installed. These can activate the governor or control valves to ensure that the intake level is maintained during periods of low flows. The output of the plant would be reduced accordingly. Typical intake details are shown in Appendix 3, Figure 3.6.

## 2.9 POWERHOUSE FEATURES

The design and location of the powerhouse is dependent on the site conditions, but its interior configuration is mainly dependent on the turbine and generator sizing. Hence the powerhouse design cannot be confirmed until the principal dimensions and requirements of the turbine and generator are established. This information is only available after consultation with the manufacturer.

Once the turbine and generator sizes have been determined, other components are fitted into the remaining floor space. Some components, such as the governor and shut off valve are closely related to the turbine location, while office, washroom, and switchgear area can be located with fewer constraints. Powerhouse cranes are expensive, but highly desirable for installation and maintenance of the equipment. Additional building functions, such as heating and ventilation must be considered in terms of the special requirements of the turbine and generator. Some typical building layouts for different types of turbines are shown in Appendix 3, Figures 3.7.1 to 3.7.7.

# 3. RESOURCE ASSESSMENT

## 3.1 BACKGROUND

A small hydro power scheme, for the purpose of this assessment, is defined as having an installed capacity of less than 20 MW. This definition conforms with the regulatory guidelines of the British Columbia Public Utilities Commission, which has streamlined the application and approval process for projects in this range.

The definition of a hydro power site as "small" is strictly a relative one. In British Columbia, where there are many large hydro power developments, 30 percent of the sites operated by BC Hydro are in the small category. Some of them may be physically quite large with generators 3 m in diameter. However, their total installed capacity is only 0.8 percent of the total capacity in the province.

The relative magnitude of the small hydro power resource must be put in the proper perspective for its importance to be appreciated. Although the energy potential is relatively small for a single site, the overall total energy potential can be significant especially when comparing the cost of developing small hydro with that of diesel power, or with new large scale projects. Furthermore, the geographical area which can be served by development of small hydro power potential is large because of the numerous sites available and the relatively low power requirement of the small communities near the sites.

Small hydro power has several inherent advantages to the community and the overall power system. The small physical size implies a relatively low impact on the environment. Many schemes, especially run of river systems, use a section of river channel that is not frequented by fish and there is only a small impoundment of water at the intake. Transmission lines are usually of lower voltages and involve simple pole type construction. The advantage to the power system is that the power sources become dispersed and less dependence is placed on a small number of power stations and river basins to supply the demand. The schemes also use a local renewable energy resource which would otherwise be untapped.

The resource assessment part of the study was directed at cataloguing the small hydro power sites that could be connected to the integrated provincial grid, dominated by large hydro power sources, or to the numerous isolated communities presently served by B C Hydro diesel generators.

The following sections described the methodology for evaluating the small hydro power resource.

## 3.2 PROJECT AREA

As indicated in Appendix 1 the area analysed in the study covers most populated parts of British Columbia. Emphasis was placed on finding small hydro power sites which could be connected to the main distribution and transmission lines of B C Hydro and West Kootenay Power and Light. Also included was a study of potential sites where B C Hydro operates diesel generating plants.

Limitations were put on how far from existing transmission lines the small hydro sites could be located. It was assumed, on the basis of preliminary economic calculations, that the furthest a 20 MW site could be away from the grid was 150 km. Smaller sites within this limit were also analysed to cover the possibility that a future transmission line may pass nearby. Isolated coastal areas were not analysed, as these were covered in a previous study (Crippen 1980). However, all areas near isolated B C Hydro diesel plants were covered to a distance which would approximate the economic limit of the appropriate small hydro power system.

There were several levels of mapping available for the project. Most of the developed areas of the province are covered by Provincial Lands Branch mapping at scales of 1:125,000, 1:126,720 and 1:100,000 with contour intervals of 200 feet, 100 feet and 50 m respectively. These maps cover the areas south of latitude 51°N plus the Fraser River to Prince George. Where supplemental mapping information was needed, Federal Government 1:50,000 topographical maps with a contour interval of 100 feet were used. For the purposes of the study, all units were converted to metric.

The above levels of mapping provide good information on the regional features and basin areas, however the contour interval limits investigation to sites of 30 m (100 ft) or more in elevation difference. There are likely to be a few sites available where there is a waterfall of less than 30 m or an unusually steep section of watercourse. Unless there is a specific elevation given beside the name of the waterfall, these sites cannot be analysed with this level of study. However, there is enough information in the report to determine the power potential and approximate cost of such sites, based on a knowledge of the head and slope.

## 3.3 EXISTING SITES

There are approximately 212 small hydro power sites licensed by the Water Rights Branch to use water for power generation. Of these, 59 are registered with an authorized installed capacity. B C Hydro operates 9 of them, while the remainder are privately owned and range in size from 3 kW to 13,320 kW. Of the 50 private sites with an authorized capacity, 40 actually have generators installed. It is not certain how many of the above sites have been abandoned.

Some of the sites mentioned have been in existence since the early 1900s. It cannot be certain if they are sized to the optimum capacity for the site, as the hydrology information used was probably based on a small amount of data. In many areas the potential of a creek is clearly not fully utilized, but then the circumstances of the plant developer may have dictated a small power requirement. Most of these projects were installed in remote areas where there was small demand for power and at a time when there was no provision in the utility regulations for private generation. In cases where the basin flow is under utilized, the proposed sites in the study are superimposed on existing sites, with the total basin capacity shown.

## 3.4 HYDROLOGY

The determination of the hydrology of the areas under investigation involved the collection of data from several sources. This information was supplemented by a study to determine the firmness of flow and the optimal installed capacity of a plant, thus enabling all projects to be compared on the same basis.

Most projects will be run of river plants and the choice of installed capacity is not obvious. In such situations it would not be rational to construct a plant large enough to utilize the peak flows, otherwise it would be operating at far below capacity most of the year. Alternatively, to size the plant for the firm flow of the creek (which is difficult to judge at best) would mean that the project is wasting water most of the year.

In order to better assess the problems of sizing the plant, several basins were analysed in different regions of the province. Project costs were estimated for various installed capacities and the energy available at each installed capacity was determined. Then the cost per kilowatt-hour was computed for each installed capacity. It was found that in all cases the cost per kilowatt-hour decreased as the installed capacity met and exceeded the mean annual flow. For en installed capacity sized for the mean annual flow, the average annual energy production was found to be in the range of 40 to 80 percent of the theoretical capability of the plant.

The implication of the findings was that the installed capacity of a plant should be sized on the basis of 80 to 120 percent of the mean annual flow. The results showed conclusively that sizing the plant for much too small a capacity greatly increased the cost of energy. The question of optimal plant sizing is then based on the following parameters:

- How much power can be utilized by the local system and at what time of the year?

- How much can the plant owner afford to pay for the installation?

- What materials and equipment are available?

The resource assessment used the mean annual flow as the basis for sizing all of the plants. The firmness factor was used as a measure of the energy available as a percentage of the theoretical annual energy. This information can then be used to compare plants on the basis of their cost in cents/kW.h.

The values for mean annual flow were determined from a map of mean annual rainfall in British Columbia (converted to a runoff in l/sec/km$^2$) from mean annual runoffs (l/sec/km$^2$) at many gauging stations throughout the province. Where a basin under investigation had similar topographic characteristics to an adjacent gauged basin the same unit runoff was used multiplied by the basin area. Where a basin covered a different precipitation zone as indicated by the precipitation map, the flow at an adjacent gauged basin was adjusted to allow for the change in precipitation. An example of the procedure is given in Appendix 2.

## 3.5 MAP STUDIES

The main effort of the study was put towards basin analysis. The various maps which had been collected were studied individually to determine the magnitude of the parameters required for each potential hydro power project as follows:

**Basin Area:** The basin area was measured using an overlay grid, direct measurements or by planimeter. The location of the intake was assumed and only the area above the intake was measured. The area was multiplied by the mean annual flow as determined in Section 3.4.

**Gross Head and Penstock Length:** The contour information was studied with a view to locating the penstock in an optimum location. The slope was maximized in order to reduce the length of penstock and the intake was located at the top of the steep section. Without the benefit of a site specific study, the contour information was assumed to be accurate and the distance of the penstock was measured on the map. The exact location of the intake will also depend on site conditions, with preference shown to areas that will minimize bedload and ice problems.

Generally, the penstock was located in an area with a stream slope greater than 10 percent, (10 vertical units to 100 horizontal units, or about 6 degrees), since the economics become unfavourable for lesser gradients. Some difficulty was encountered with evaluating low head plants because information on the available mapping did not always show a waterfall or steep section. If such a change in grade occurs between two adjacent contour lines, a potential site can be found only by an air photo study or local knowledge. In the cases where a waterfall of uncertain height exists, the report describes the site and gives the flow, so that the power output can be calculated when the waterfall height is determined. In areas that are using diesel generated power, lesser stream gradients were analyzed, as low as 5 percent.

**Distance to Transmission Line:** As the purpose of the study was to locate projects that can be tied into existing transmission lines, it is important to know the voltage rating and proximity of the nearby transmission lines. This information was obtained from transmission and distribution line mapping provided by B C Hydro and West Kootenay Power and Light and plotted on the contour maps.

The distance to the existing lines was scaled off the map, following roadways where possible. The voltage rating of the interconnecting transmission line would be determined by its length, power input, and in some instances by the voltage rating of the existing line.

**Access Road.** Most sites are located fairly close to existing secondary roads. However there are some areas where new roads must be provided for construction and maintenance, and others where the size of the installation will require road upgrading. These factors were considered when the access road distance was measured.

**Site Factor.** The site factor was applied to the standard unit costs used in the cost analysis program. It is based on a judgement of the conditions of the site and can range from 1.0 for sites with good access located near large towns to 1.5 for sites that are remote without support facilities. The increase reflects the higher costs that a contractor will face on isolated jobs.

## 3.6 DESIGN STANDARDS

After determining the basin parameters as in Section 3.5, this basic information was assembled and input to a computer program. The program calculated the approximate dimensions of the main project components, as discussed below.

**Installed Capacity:** The installed capacity was based on the mean flow and the head using the formula: Gross Head (m) x Flow ($m^3/s$) x 7 = Capacity (kW).

**Intake:** The intake was sized in proportion to the flow in the penstock and provided with sufficient trash screen area to admit water at less than 0.6 m/sec. The intake is the most difficult component to estimate because its configuration is mainly site specific.

**Penstock:** The penstock was sized to allow a maximum head loss of 10 percent or a maximum velocity of 3.8 m/sec. The design was based on using steel pipe, which can be used in any situation. This simplifies the cost calculation when there is little site specific information available. The pipe was sized to have a minimum 6 mm wall thickness. Support structures (anchor blocks and pedestals) were assumed to occur at intervals of 12 metres along the penstock. This would vary with the actual elevation and thickness of the penstock. A surge tank was not included, because it usually amounts to only about 5 percent of the penstock cost, if it is required.

**Turbines:** Each project was designed for one turbine with a generator running at a synchronous speed. General design text guidelines were used for choosing a speed and type of turbine with due consideration of the cavitation limits. A selection table was incorporated into the computer to choose a speed and turbine type from the head and flow information.

**Powerhouse:** The powerhouse sizing is mainly dependent on the turbine and generator size. At this level of study horizontal shaft units were assumed, which maximizes the floor area used. The building was sized for unattended operation, that is, only the essential facilities are provided with no conveniences for the plant operator.

**Power Transmission:** Feederlines run from the generating plant to the nearest point of connection to existing transmission lines and it was assumed that interconnection with the existing system can be made at these points. Details of the electrical interconnection are not included at this level of study.

Transmission line information is shown as if only one project were constructed. In fact, there could be several projects in an area which could benefit from the installation of one line. These details would need to be determined when projects are brought to the design stage.

## 3.7 PROJECT ANALYSIS

Once the basin parameters (through the map study) and the design standards (calculated from basin parameters) have been determined, a small hydro power project has been conceptualized. It remains to account for some less obvious factors that go into the decision to proceed with a site specific feasibility study.

The location of the project is probably the most critical factor. The stream between the intake and the powerhouse should not be a migratory area for fish. If the location infringes on a park, the Parks Branch approval would be required, and other land conflicts with forestry, private and crown land must be settled.

The relationship of the project with respect to the nearest transmission or distribution line is important because the characteristics of the system at that point can affect the overall project cost. Interconnection will have to be made at a compatible system voltage, within the capacity of the existing lines and using equipment and practices approved by the utility. The purchasing utility must be contacted at an early stage to determine its interconnection policy.

Accessibility must be a concern for the owner of a project, as the plant must be serviced and maintained. The size of a project is relevant, because for a small plant the effort to maintain it may not be justified if it is too remote. Winter maintenance is also a concern in isolated or mountainous regions, both for the effects of cold on the plant and increased difficulty of access.

A site inspection must be carried out at an early stage in the project. Map studies must be improved by air photo analysis, which combined with a site inspection would indicate landslide hazards, bedload conditions, foundation conditions and the overall characteristics of the terrain.

The economics of the project, which will partly determine whether construction can proceed, will be determined at several levels of the study. As each stage of the study is completed, the costs and benefits should again be evaluated. Economic parameters derived from the initial stages are described below:

**Mean Project Cost:** The computer program calculates a mean cost for each project, based on the best estimates of the site parameters and the cost indices which are built into the program. Separate cost curves were used for the intake, penstock, powerhouse (including equipment), access road and transmission line, although the transmission line cost is not included at this level of study. A contingency allowance and the cost of engineering are applied as percentages to the total construction cost.

**Mean cost/kW.h:** The mean project cost calculated above is divided by the average annual energy that could be generated, and multiplied by the assumed discount rate of 5 percent. The discount rate is defined as the rate of interest minus the rate of inflation. This is a means of ranking projects but the actual cost would depend on how the project is financed.

**Cost Range/kW.h:** The data input into the computer program is adjusted for the uncertainty in the hydrology and cost information. The estimated mean annual flow is given a range, depending on the proximity of a gauged basin and the length of record. This information also affects the firmness of flow, which is used to derive the average annual energy available. Further uncertainties are applied to the cost estimates and the discount rate to get a range of cost/kW.h. There are other uncertainties which exist in the project analysis, and these can only be evaluated with more detailed study, especially site investigation. Contour intervals on the maps limit the accuracy to which the gross head can be calculated, and also the determination of the penstock length. More accurate mapping and a site inspection would also assist in determining the drainage area and in visualizing any construction difficulties.

# 4. PROJECT FEASIBILITY

## 4.1 INTERCONNECTION POLICIES

Small hydro power sites can be developed strictly to suit the needs of the Owner or for serving a larger power market. The feasibility of the former type of project will depend on the Owner's resources and alternative power sources. Projects serving a larger market, which in this study is defined to be the provincial electric grid, require a definitive interconnection policy provided by the local utility, covering the technical and commercial aspects of small hydro power projects and distinguishing various size ranges.

Most of the background information is available from United States sources. The status of small hydro power development in the United States is such that the development of the resource is ahead of British Columbia in respect of utility interconnections, although British Columbia has its share of isolated systems. Most United States utilities have developed their policies based on the PURPA (Public Utility Regulatory Policies Act) legislation. A few examples of these policies are described as follows:

### Oglethorpe Power Corporation (Georgia) (OPC)

The interconnection policy of the Oglethorpe Power Corporation is limited to qualifying facilities (QF) that produce power directly or through cogeneration with the facility meeting FERC (Federal Energy Regulatory Commission) rules. Legally the utility must cooperate with the qualifying facility but it has considerable say in the design and operation of such facilities.

Technical System Guidelines including Interconnection Practice, Protection, Metering and System Operating Requirements are all clearly covered in the Oglethorpe Interconnection Policy Manual. Technical requirements vary with the size of plant, system connection and voltage rating of the associated transmission or distribution lines. Installations are broken down into six main classifications recognizing different operating characteristics and protection requirements as follows:

| Type | Generator Size | Phases | System Connection | Power Interchange Either Direction |
|---|---|---|---|---|
| 1 | 5000 kW or greater | 3 | Network Line | Yes |
| 2 | 5000 kW or greater | 3 | Network Bus | Yes |
| 3 | 5000 kW or greater | 3 | Radial Line | Yes |
| 4 | 101 - 5000 kW | 3 | Radial Line | Yes |
| 5 | 11 - 100 kW | 3 | Radial Line | Yes |
| 6 | 0 - 10 kW | 1 | Radial Line | Yes |

Generally speaking, OPC provides all interconnection facilities, at the expense of the QF, including all protective and metering equipment which OPC owns, operates and maintains. The QF designs and provides the generating system subject to OPC approval.

Qualifying generation facilities enter into a written contract with OPC. Rates governing the purchases of capacity and energy are established by OPC for the smaller capacity installations and arrived at by negotiation for the installations over 5000 kW. OPC reserves the right to conduct a special analysis of the cost impact and to adjust the rates accordingly.

### Seattle City Light (Washington) (SCL)

The policy of Seattle City Light is to interconnect with qualifying small power and cogenerating facilities and to make possible the purchase and sale of electricity. Their policies and procedures which are based on PURPA legislation are presently only available in draft form. They provide the prospective power producer with general information on the approval process, design and installation requirements in conjunction with a separate document, entitled **Interconnection Requirements.**

All electrical apparatus required to control the generator and to tie it into the Utility System at the point of interconnection, including transformers, switchgear and protective relaying are furnished, installed, operated and maintained by the qualifying facility.

Utility equipment required for the interconnection, including metering, is provided and maintained by SCL. Design and specifications of the complete installation are subject to SCL review and approval.

Power is purchased under contract and rates are set in accordance with avoided costs for energy and capacity.

### Portland General Electric Company (Oregon) (PGE)

The interconnection requirements of the Portland General Electric Company are simply stated in their regulations, **Electric Service Requirements for Single-Phase and Three-Phase Parallel Generation.** Subject to design approval, they provide for customer owned generation to operate in parallel with their system where the customer provides all of the electrical apparatus required for generator control, protective relaying and interconnection. Regulations are now available for the connection of systems less than 100 kW, and regulations are being drafted for larger systems.

### B C Hydro (British Columbia) (BCH)

The cogeneration and interconnection policies of B C Hydro have not been finalized. In the light of revised load growth forecasts, the utility is taking a cautious approach to the subject of interconnections to the provincial grid and a definitive policy was not available. In areas that are presently served by diesel generation, there are some better defined cost savings to be made if small hydro power systems can be connected. B C Hydro will evaluate proposals and negotiate rates of payment in diesel areas on an individual basis.

**West Kootenay Power and Light (British Columbia) (WKPL)**

West Kootenay Power and Light Company serves many communities in southern British Columbia from Kelowna and Keremeos to Creston. They encourage the development of small hydro power sources, as the system must rely on transfers of power from the B C Hydro system to meet its peak demands. The technical requirements are typical of most utilities, where protection of the overall system and the customer owned generator must be coordinated (and paid for by the customer). Initiating the process to satisfy the technical, legal and commercial terms can be done at any of the district offices. WKPL rates will be variable as to the time of day and the time of year.

## 4.2 WHEELING POWER

The concept of wheeling power is not new but its application to small hydro power projects in British Columbia has not yet been tried. Wheeling involves the transfer of power from a producer to a customer, through the tranmission lines of a third party (utility) not directly involved with the other two. Both B C Hydro and West Kootenay Power and Light supply power to California customers through the transmission lines of Washington and Oregon. All of the West Coast utilities from California to British Columbia are in the Northwest Power Pool and these arrangements benefit all of them at one time or another, as firmer power supplies are established. The cost of transmission is nominal and paid to the utility wheeling the power.

It may be possible for a small hydro power producer located in the B C Hydro system to establish a contract with West Kootenay Power, who would take the appropriate amount of power through their interties with B C Hydro. The small hydro power producer would still have to meet the technical requirements of the utility to which it was directly connected. In order for this arrangement to be widely used, definitive policies will need to be established by both B C Hydro and West Kootenay Power and Light.

In the extreme, a private power supplier with a need for power may be able to wheel power to itself, using the stability of the utility to control its self generated power. A two way arrangement of power transfers would need to be arranged so that when the utility fed power in the normal billing would apply, while when the supplier fed power out it would displace the suppliers own need for power. Even if the utility did not pay for power supplied, there could be advantages to the supplier if the supplier's generator was well matched to the supplier's loads.

## 4.3 COST ESTIMATES

The capital cost of each small hydro power project was based on a combination of experience curves, cost curves in literature and unit price data, all adjusted to 1982 price levels. Separate cost curves were used for intakes, penstocks, powerplants and transmission lines. Percentages were applied to the total for engineering services and for a contingency allowance.

The cost of the generating facility for a project was separated from the transmission line cost, in case the transmission line was long and created a disproportionate cost index. This permits each project to be analyzed in more detail and allows for a better rating where several adjacent projects share a transmission line or if a new transmission line is built into the area.

The cost of the power produced by the small hydro power station is estimated by taking the annual cost of the project divided by the average energy generated per year. The annual cost of the project is normally calculated by taking the cost of amortization over 40 years (the plant life) and adding in the cost of the annual maintenance and operating expenses. In this study a rate of 5 percent was used. This approximates the interest rate net of the inflation rate, and provides a practical index for comparing the potential small hydro power sites. A more rigorous analysis is provided in the companion volume to this report, **Small Hydro Power Resource in the Provincial System, Economic and Financial Assessment**.

The annual energy generation is taken as the total number of kilowatt-hours of energy which could be generated in a year. It is assumed that the plant will generate at a rate equivalent to the energy available in the water, up to the installed capacity. For run of river plants with no storage, this is taken as the theoretical annual energy (based on full generation at the installed capacity) multiplied by the firmness factor (which accounts for the periods when there is insufficient flow to meet the installed capacity). The resulting cost of power (in cents per kilowatt-hour) is a means of comparing different sites with a common parameter, and relating the cost to current rates payable for power. Once a project has been studied further, the actual unit cost of power must be determined by a more detailed financial analysis.

## 4.4 REVENUE ESTIMATES

The preliminary analysis of the small hydro power project must estimate the annual revenue of the project for comparison with the annual cost. It is assumed that the rate of payment for power supplying the provincial grid may be about 2 cents/kW.h (1982), but this rate has not been fixed by either B C Hydro or West Kootenay Power and Light. The rate of payment must be modified by the water tax, currently set at .314 cents/kW.h (1982) and payable to the Provincial Government. Where the small hydro power system is supplying a diesel powered system, (where the cost of energy is at least 10 cents/kW.h), the rate of payment should be set much higher to reflect the avoided costs of the utility. Section 27 of the British Columbia Utilities Commission Act allows the BCUC to rule on rates paid to private suppliers.

The theoretical annual revenue is found by multiplying the net rate of payment by the installed capacity, the firmness factor, and the number of hours in a year (8760). The actual revenue would be less than this to account for production losses during maintenance and repairs. Therefore over the long term, the actual revenue should be about 90% of the theoretical, assuming that the utility will accept all of the power that the small hydro power installation can produce.

## 4.5 FINANCIAL CONSIDERATIONS

The financial feasibility of a small hydro power development can be evaluated in the same way as any capital investment that produces a stream of benefits as a cash flow.

As a project is conceived and designed, it should be analyzed for its economic feasibility at each step. The comparison of present value costs to present value benefits should be the main criteria in making the decision to proceed to the next stage of investigation. Feasibility can also be determined by comparing the internal rate of return on investment to a target rate.

A preliminary analysis has revealed it is possible for a small project to be financially feasible even if it experiences a few years of negative cash flow at the beginning. Taxation benefits or penalties and possible government assistance will influence the feasibility of the project.

Further discussion of financial feasibility is beyond the scope of this study, and is covered in the companion report.

# 5. MAGNITUDE OF THE SMALL HYDRO POWER RESOURCE

## 5.1 POTENTIAL SMALL HYDRO POWER SITES

The potential small hydro power sites covered by this study are listed in the tables of Appendix 1. Each group of tables is keyed to a map in Appendix 1. The key parameters used to evaluate each site are described in Sections 3.5, 3.6 and 3.7 and are listed in the tables in Appendix 1.

The 665 small hydro power sites analyzed have a total possible installed capacity of 1439 MW. These are separated into grid power areas and non-integrated diesel areas as shown on the maps in Appendix 1. The regional totals are shown in Table 5.1. Determination of potential power output in the remainder of the province was beyond the scope of this report, but an estimate was made based on power availability in adjacent areas that were analysed.

**Grid Power Areas:** The number of potential sites which could be connected to the grid is estimated at 553 with a total capacity of 1189 MW. These sites have not been ranked according to their economics, although the cost indices indicate which are the more attractive sites. For the purposes of this study, only those sites with an installed capacity greater than 100 kW were catalogued. Based on the proportion of existing plants less than 100 kW to the overall total, it was estimated that a further 35 MW of capacity may be available in sites with less than 100 kW capacity.

**Diesel Power Areas:** Investigations were carried out in the areas served by non-integrated BC Hydro diesel generators. The total capacity located within these areas is about 250 MW in 112 sites, as shown in the Tables. BC Hydro's avoided cost of generation in these areas is 10¢/kW.h or more, hence the economic limit of these plants is much higher than in grid areas where the net power value could be about 2¢/kW.h.

**Isolated Areas - (Not Connected to Power Distribution Systems):** Based on the area covered by the grid and diesel regions, a rough estimate of the remaining provincial potential for small hydro power is 954 MW. Many of these areas not covered by the grid and diesel assessments in this report are inaccessible or so remote as to not require power in any quantity. The estimate must be treated with caution as it is statistically derived and the development of the resource in these areas is uncertain.

## 5.2 WATER LICENSES HELD AT UNDEVELOPED SMALL HYDRO POWER SITES

As indicated in Section 3.3 there are about 150 sites which are licensed for power production by the Water Rights Branch, but which currently have no record of having generators installed. It is known that some of these sites do have generators installed but it is considered that most of the locations are categorized correctly. The total flow licensed is about 11 $m^3/s$ or an average of 70 l/sec per site. This is not a significant amount but any subsequent development on the same creek would have to consider the prior rights of the first licence holder.

These licensed locations are generally owned by individuals, and are a mixture of remote sites and sites which may be close to existing distribution lines. The parties holding these licences were in most cases considering only their own power requirements when they applied for their licence, hence they would usually have little water available for use in generating power to be sold.

## TABLE 5.1
## SMALL HYDRO POWER SITES IN BRITISH COLUMBIA

### Integrated (Grid) and Non-Integrated (BC Hydro Diesel)

| Region | Number of Sites | Capacity<br>MW | Energy<br>GW.h/yr |
|---|---|---|---|
| 1 | 146 | 271 | 1150 |
| 2 | 146 | 510 | 2508 |
| 3 | 161 | 215 | 1220 |
| 4 | 45 | 80 | 348 |
| 5 | 26 | 81 | 423 |
| 6 | 23 | 86 | 489 |
| 7 | 23 | 40 | 174 |
| 8 | 39 | 58 | 303 |
| 9 | 19 | 30 | 179 |
| 10 | 0 | 0 | 0 |
| 11 | 24 | 47 | 230 |
| 12 | 0 | 0 | 0 |
| 13 | 13 | 21 | 78 |
| TOTAL | 665 | 1439 | 7102 |

## SMALL HYDRO POWER SITES
## NEAR EXISTING B C HYDRO DIESEL GENERATING SYSTEMS

| Region | Number of Sites | Capacity<br>MW | Energy<br>GW.h/yr |
|---|---|---|---|
| 3 | 29 | 23 | 111 |
| 5 | 21 | 79 | 415 |
| 6 | 23 | 86 | 489 |
| 7 | 15 | 26 | 112 |
| 9 | 5 | 42 | 24 |
| 11 | 6 | 12 | 56 |
| 13 | 13 | 21 | 77 |
| TOTAL | 112 | 250 | 1,284 |

**NOTE:** The number of sites listed above and in the tables of Appendix 1 represent the first approximation of the resource, based on mapping of limited detail and generalized hydrology patterns. The viability of any scheme can only be determined after field investigation, detailed hydrology study and detailed financial analysis.

## 5.3 EXISTING SMALL HYDRO POWER INSTALLATIONS

As discussed in Section 3.3 there are about 49 sites with licensed generation capacity and machines installed. In this section a few case studies are provided as examples of the range of sizes and interconnections covered by small hydro power development.

### Shuswap Falls Generating Station
### 5200 kW - BC Hydro

This station is about 50 years old and takes advantage of a natural waterfall in the Shuswap River. At one time it supplied the electrical needs of the North Okanagan, but now it supplements the grid, as it has insufficient capacity for the entire area. The plant has some flow regulation provided by a storage dam 17 miles upstream.

The basic system components include a concrete arch storage dam and spillway channel blasted from rock. Twin 2.4 m diameter wood stave penstocks lead to the differential surge tanks and the concrete powerhouse. Within the powerhouse are two vertical shaft turbine generator units, rotating at about 225 RPM and rated for 24 m head. Power is fed to the grid via a 10 mile long, 25 kV tie line.

### Clayton Falls Generating Station
### 700 kW - BC Hydro

This station, about 20 years old, supplies a mixed hydro/diesel system at Bella Coola. Most of the time it is locked on to its full output, but occasionally it must swing with load variation while a diesel is locked on a fixed load.

The system consists of a river intake, and a 750 mm diameter wood stave penstock leading to a steel frame powerhouse. A horizontal shaft Francis turbine is used to turn the 720 RPM generator which feeds power to the switchyard 6.5 km away at the diesel station.

### Kingcome Hydro Power Project
### 75 kW (Unit 1) - Tsawataineuk Band

The Kingcome Project has recently been commissioned and is an example of a run of river, off-grid site. It supplies power to an isolated Indian village on the coast, and it is to be coordinated with a standby diesel installation. The diesel and hydro power sources will only operate in isolation, as they are not designed to run in parallel

The project features an intake in a natural pool along a creek, with a 250 mm diameter polyethylene penstock leading 2/3 of the way to the steel frame powerhouse. The remainder of the penstock is steel. The water at 150 m of net head spins a Crossflow turbine at 1200 RPM, coupled to a synchronous generator. Power is transmitted at the 2.4 kV level for 1.5 km to the 20 homes in the village.

The project is designed to be expanded, requiring only an extension of the powerhouse and the addition of a second 75 kW unit and a synchronizer in the powerhouse.

### Klemtu Hydro Power Project
### 320 kW (Unit 1) - Kitasoo Band

The Klemtu Project is an example of an off-grid site with storage. A natural lake is controlled with a low dam, and the water drops about 260 m in a 350 mm diameter, 675 m long steel penstock to the Pelton wheel turbine. The turbine rotates at 1200 RPM to drive a synchronous generator.

The project is designed to be expanded, requiring only the addition of a second unit of about 320 kW and a synchronizer in the powerhouse. It can also be isolated and a standby diesel run during times the plant is shut down for maintenance.

# 6. SUMMARY AND RECOMMENDATIONS

## Summary of Provincial Potential

The total provincial potential for small hydro power in British Columbia is estimated to be about 2400 MW, covering electrically integrated, non integrated and isolated areas. Much of this potential is presently too expensive to develop, but under more favourable economic conditions (higher prices for electricity and lower interest rates), the potential sites would be more attractive. There are also a number of attractive sites which, because of their isolation, are not feasible to develop until a transmission line passes closer to them.

The economic balance between sites near the integrated and non integrated systems of British Columbia is indicated by reference to Table 5.1. The number of sites near the grid is about 550 with a potential generation of about 5800 GW.h/yr while the number of sites near B C Hydro diesel generating systems is about 110 with an energy potential of about 1300 GW.h/yr. Using a value of about 2¢/kW.h for grid power, the sites near the grid could generate $116 million worth of power every year, while the sites replacing diesel at 10¢/kW.h could generate power worth $128 million per year. These values are subject to more detailed site and market investigations.

The additional 954 MW of installed capacity estimated to be located in isolated areas would produce power valued at more than 10¢/kW.h because the markets would usually have diesel power as an alternative.

The companion volume to this report, **Small Hydro Power Resource in the Provincial System, Economic and Financial Assessment**, builds on the cost data developed here in order to determine the economic feasibility and the financial viability of the resource as it applies to the integrated grid and to the BC Hydro diesel systems.

## Recommendations for Implementation of Small Hydro Power Systems in British Columbia

The implementation of a small hydro power scheme involves a number of steps, requiring consultation with various branches of government, manufacturers, utilities and possibly contractors. The first step is evaluation, where the physical, technical and financial constraints of the project are assessed. As the size and value of the project increases, it becomes more important to utilize competent professional services.

Once the technical and economic feasibility of a project is assured the small hydro power producer must establish a long term contract with a utility for the purchase of power. Further development of interconnection policies by both B C Hydro and West Kootenay Power and Light are required to enable the small hydro power producer to properly assess the technical and commercial terms, which play a major part in determining the project feasibility. The concept of wheeling power between utilities should also be established so that small hydro power producers can have a wider market for their power.

When a project is conceived and a market for the power established, it remains for the prospective small hydro power producer to arrange financing, complete the design and construct the power plant. This procedure involves considerable planning, expertise and careful cost control at each step to ensure that the project is technically sound and is built for the allocated budget. Cost overruns can make the difference between a successful (profitable) and an unsuccessful project. It also becomes vitally important to ensure that the power production and hence the cash flow, are maximized. This can best be done by optimizing the plant operation to use as much of the available flow as possible, and to keep the plant in operation by adhering to prescribed maintenance procedures.

The development of small hydro power in British Columbia is at a point where there could be a significant increase in activity, given some increased awareness and the right set of economic circumstances. As a step in this direction Energy, Mines and Resources, Canada has initiated the Remote

Community Demonstration Program, which is designed to fund studies to prove out a range of alternative energy projects in isolated areas. Other incentives are available through tax savings to investors in small hydro power plants, and there is probably room for additional incentives. In the long run however, there must be clear economic advantages to the utilization of small hydro power systems, advantages that benefit the public as well as the power producer. A more detailed economic and financial assessment is presented in the companion report, but the overall outlook for the resource is optimistic in terms of the number of sites and the potential value of the energy.

## 7. REFERENCES

(1) ENERGY, MINES AND RESOURCES CANADA (CRIPPEN CONSULTANTS): **Micro Hydro, A Survey of Potential Micro Hydro Developments for Use By Small Communities in British Columbia,** October 1980.

(2) B C HYDRO: **Draft Policy, Customer Owned Generation of Electricity,** 1982.

(3) OGLETHORPE POWER CORPORATION: **Interconnection Policy,** 1981.

(4) SEATTLE CITY LIGHT: **Draft Policy - Cogeneration and Small Power Production Facilities.**

(5) WOODWARD GOVERNOR COMPANY: **Type UG Hydraulic Turbine Control,** 1979.

(6) TUDOR ENGINEERING: **Reconnaissance Evaluation of Small Low Head Hydroelectric Installations,** 1980.

(7) UNIVERSITY OF CALIFORNIA, BERKELEY: **Building and Operating a Small Scale Hydroelectric Power Plant (Conference Proceedings),** 1982.

(8) GILBERT GILKES & GORDON LTD: **Gilkes Water Turbines for Hydro-Electric Power,** 1970.

(9) STAPENHORST INC: **Ossberger Turbine Generating Sets.**

(10) U S ARMY CORPS OF ENGINEERS: **Feasibility Studies for Small Scale Hydropower Additions - A Guide Manual,** 1979.

(11) GINGOLD, P R: **The Optimum Size of Small Run-of-River Plants,** Water Power and Dam Construction, November 1981, pp 50-51.

(12) GORDON, J L and PENMAN, A C: **Quick Estimating Techniques for Small Hydro Potential,** Water Power and Dam Construction, September 1979, pp 46-51.

(13) AGOSTINELLI, A and SHAFER, L: **Using Pumps as Small Turbines,** Water Power and Dam Construction, November 1981, pp 58-59.

(14) PORTLAND GENERAL ELECTRIC COMPANY: **Small Power Production and Interconnection Package,** April 1982.

(15) SIGMA ENGINEERING LTD: **Small Hydro Power Resource in the Provincial System, Economic and Financial Assessment,** Ministry of Energy, Mines and Petroleum Resources, British Columbia, July 1983.

# APPENDIX 1

## RESOURCE MAPS AND TABLES

# LIST OF MAPS

| Figure | Area |
|---|---|
| 1 | Kootenay |
| 2 | Vancouver - Okanagan |
| 3 | Vancouver Island |
| 4 | Thompson - Columbia |
| 5 | Cariboo - Chilcotin |
| 6 | Central - Coast |
| 7 | Prince George |
| 8 | Kitimat - Nechako |
| 9 | Prince Rupert - Queen Charlottes |
| 10 | Fort St John |
| 11 | Skeena |
| 12 | Fort Nelson |
| 13 | Northwest |

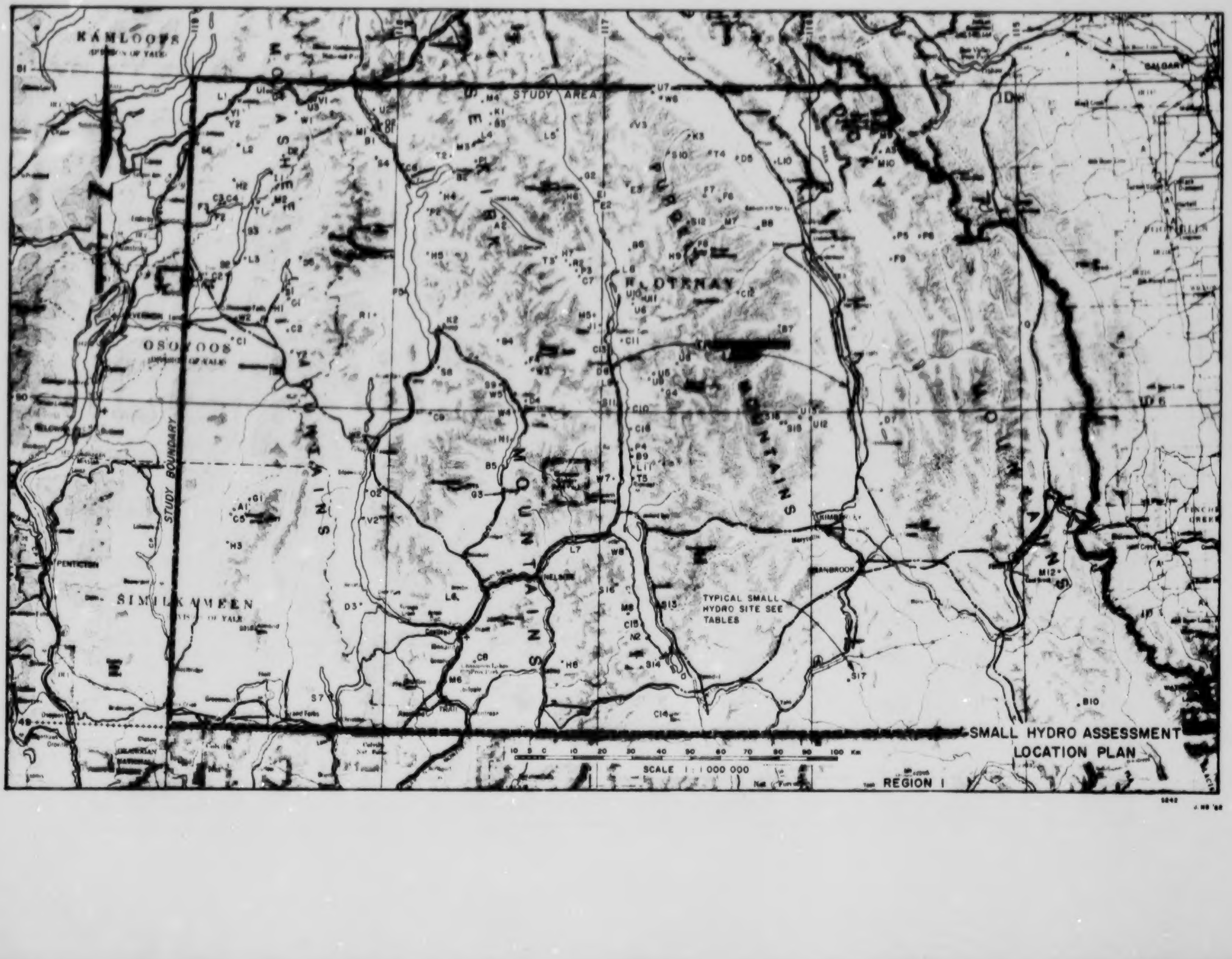
# EXPLANATION OF MAPS AND TABLES

| MAP DESIGNATION | DESCRIPTION |
|---|---|
| K2 | Site name, begins with letter K, Numbers are sequential moving from the Northwest to Southeast. |
| D | B C Hydro diesel site, off grid. |
| Study Boundary | Indicates the boundary of the map. |
| Study Area | Indicates the portion of the map which was analysed for small hydro power sites. |
| Transmission Lines | Corridors which contain all voltages of transmission lines are shown. Where only 138 kV lines and up are present, an analysis may not have been made, because it may not be feasible to connect even a 20 MW plant. |

| TABLE DESIGNATION | DESCRIPTION |
|---|---|
| Lat., Long | Latitude and longitude of the site. |
| K2 | Corresponds to a site on the map. |
| Basin Size | Area above the intake in square km. |
| Design Flow | Mean annual flow in $m^3/s$. |
| Frac. Firm. | The fraction of firmness or firmness factor. The actual energy available is the installed capacity x 8760 x Frac Firm. |
| Head | Vertical distance between intake and powerhouse in metres. Sites with less than 30 m of head cannot be analysed because of mapping limitations. |
| Pen.Len.,Dia. | Penstock length and diameter in metres. |
| Access Road | Length of access road in kilometres. |
| Line kV/D | Nearest transmission line voltage and distance. The suitability of the existing line to accept the power has not been checked. |
| Inst. Cap. | The installed capacity in kilowatts. |
| Cost ($1000) | The estimated total capital cost in thousands of dollars (not including transmission line) |

## EXPLANATION OF MAPS AND TABLES

| TABLE DESIGNATION | DESCRIPTION |
|---|---|
| Cost ¢/kW.h | The average cost of power production based on a discount rate of 5%. For comparison only as actual costs must be based on financial analysis. |
| Cost Range | The uncertainties of flow, head, and construction cost are combined to give a most probable cost range in cents/kW.h. |
| N/A | Where waterfalls or rapids are shown on the mapping, but the height is not given, the site is shown as a potential one. Until the height is determined the remaining information is not available. |



KAMLOOPS
DIVISION OF YALE
STUDY AREA
STUDY BOUNDARY
OSOYOOS
DIVISION OF YALE
SIMILKAMEEN
DIVISION OF YALE
MONASHEE MOUNTAINS
SELKIRK MOUNTAINS
PURCELL MOUNTAINS
KOOTENAY
ROCKY MOUNTAINS
N
NELSON
CRANBROOK
KIMBERLEY
PENTICTON
CALGARY
TYPICAL SMALL HYDRO SITE SEE TABLES
10 5 0 10 20 30 40 50 60 70 80 90 100 Km
SCALE 1 : 1 000 000
49
117
118
115
116
119
50
51

SMALL HYDRO ASSESSMENT
LOCATION PLAN
REGION I

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ARTHURS CR<br>A1 | 49 41<br>118 43 | 33 | .40 | .40 | 280 | 2000<br>.44 | 7.0 | 25<br>50 | 800 | 3600 | 6.4 | 2.9<br>14 |
| ASHER CR<br>A2 | 50 36<br>117 29 | 113 | 3.4 | .53 | 150 | 2100<br>1.1 | 6.0 | 25<br>54 | 3600 | 9100 | 2.7 | 1.5<br>4.8 |
| ASSINIBOINE CR<br>A3 | 50 48<br>115 40 | 22 | .53 | .50 | 240 | 1500<br>.48 | 25 | 25<br>47 | 900 | 5600 | 6.8 | 3.7<br>12 |
| BEATRICE CR<br>B5 | 49 50<br>117 28 | 138 | 4.1 | .45 | 165 | 750<br>.98 | 10 | 25<br>7.0 | 4900 | 5800 | 1.5 | 0.8<br>2.9 |
| BEATTON CR<br>B2 | 50 44<br>117 44 | 99 | 2.8 | .63 | 150 | 2000<br>1.0 | 0.0 | 25<br>50 | 3000 | 7300 | 2.2 | 1.5<br>3.3 |
| BEHRMAN CR<br>B6 | 50 30<br>116 52 | 20 | .70 | .50 | 240 | 850<br>.88 | 5.0 | 25<br>34 | 1230 | 2500 | 2.3 | 1.0<br>5.2 |
| BEN ABLE CR<br>B7 | 50 16<br>116 09 | 42 | .63 | .50 | 180 | 1400<br>.53 | 8.0 | 25<br>33 | 830 | 3200 | 4.4 | 2.3<br>8.6 |
| BERNARD CR<br>B9 | 49 52<br>116 51 | 55 | 1.7 | .45 | 180 | 1200<br>.75 | 1.0 | 25<br>20 | 2200 | 3400 | 1.9 | 1.0<br>3.7 |
| [illegible]T CR FALLS | 50 50<br>118 05 | 75 | 3.4 | .45 | N/A | N/A<br>N/A | 0.0 | 25<br>21 | N/A | N/A | N/A | N/A<br>N/A |
| BOYD CR<br>B3 | 50 53<br>117 34 | 58 | 2.2 | .53 | 250 | 1800<br>.84 | 10 | 25<br>64 | 4000 | 7100 | 1.9 | 1.2<br>3.2 |
| BRENNER CR<br>B4 | 50 13<br>117 30 | 77 | 3.5 | .47 | 120 | 1900<br>1.2 | 2.0 | 25<br>26 | 3000 | 7700 | 3.0 | 1.8<br>5.1 |
| BRUCE CR<br>B8 | 50 34<br>116 15 | 79 | 2.4 | .52 | 50 | 400<br>.88 | 10 | 25<br>12 | 850 | 3400 | 4.4 | 2.3<br>11 |
| CAMPBELL CR<br>C16 | 49 57<br>116 51 | 88 | 2.7 | .45 | 240 | 2400<br>.97 | 9.5 | 25<br>28 | 4800 | 11000 | 2.9 | 1.5<br>5.6 |
| CARIBOU CR<br>C9 | 49 59<br>117 50 | 202 | 6.1 | .45 | 120 | 1350<br>1.3 | 0.0 | 25<br>2.5 | 5300 | 7200 | 1.7 | 0.9<br>3.3 |
| CASCADE CR<br>C7 | 50 25<br>117 07 | 70 | 1.9 | .47 | 180 | 1800<br>.84 | 0.0 | 25<br>14.5 | 2500 | 5500 | 2.7 | 1.7<br>4.3 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHAMPION CR<br>C8 | 49 14<br>117 35 | 73 | .95 | .40 | 92 | 500<br>.58 | 2.0 | 25<br>4.0 | 630 | 1600 | 3.6 | 2.0<br>6.6 |
| CHRISTIAN CR<br>C2 | 50 24<br>118 48 | 24 | .19 | .45 | 200 | 900<br>.36 | 3.0 | 25<br>2.0 | 290 | 1400 | 6.1 | 1.7<br>23 |
| CLINT CR<br>C11 | 50 13<br>116 54 | 69 | 2.4 | .50 | 243 | 2000<br>.89 | 1.0 | 25<br>1.0 | 4200 | 6800 | 1.8 | 0.8<br>4.2 |
| CLUTE CR<br>C10 | 50 01<br>116 53 | 23 | .81 | .50 | 609 | 3200<br>.55 | 8.0 | 25<br>8.0 | 3500 | 8700 | 2.8 | 1.2<br>6.5 |
| COCHCRANE CR<br>C5 | 49 40<br>118 44 | 44 | .53 | .40 | 500 | 2600<br>.47 | 4.5 | 25<br>45 | 1900 | 5000 | 3.7 | 1.7<br>8.1 |
| COOKE CR<br>C3 | 50 37<br>118 50 | 64 | 1.9 | .45 | 200 | 2100<br>.86 | 0.5 | 25<br>0.5 | 2700 | 6200 | 2.8 | 1.1<br>7.4 |
| COOKE CR FALLS<br>C4 | 50 36<br>118 50 | 68 | 1.9 | .45 | N/A | N/A<br>N/A | 0.5 | 25<br>1.3 | N/A | N/A | N/A | N/A<br>N/A |
| COOPER CR<br>C13 | 50 12<br>116 59 | 183 | 4.6 | .47 | 183 | 5100<br>1.4 | 1.5 | 25<br>1.5 | 6000 | 29500 | 6.0 | 2.8<br>13 |
| COPPERCROWN CR<br>C12 | 50 22<br>116 21 | 20 | .30 | .50 | 183 | 1000<br>.41 | 0.0 | 25<br>24 | 400 | 1400 | 3.8 | 1.9<br>7.4 |
| CORN CR<br>C14 | 49 04<br>116 40 | 100 | 2.3 | .55 | 60 | 800<br>.96 | 1.0 | 25<br>4.0 | 990 | 3200 | 3.4 | 2.0<br>5.8 |
| CRAWFORD CR<br>C6 | 50 45<br>117 59 | 27 | 1.1 | .53 | 250 | 1300<br>.61 | 1.0 | 25<br>21 | 1900 | 2900 | 1.6 | 1.0<br>2.7 |
| CREIGHTON CR<br>C1 | 50 12<br>118 46 | 32 | .30 | .47 | 200 | 1800<br>.39 | 0.5 | 25<br>2.0 | 380 | 1900 | 5.9 | 2.8<br>12 |
| CULTUS CR<br>C15 | 49 20<br>116 47 | 168 | 3.9 | .55 | 123 | 1800<br>1.2 | 4.0 | 25<br>27 | 3400 | 8400 | 2.5 | 1.5<br>4.4 |
| DAVIS CR<br>D6 | 50 08<br>116 57 | 39 | .80 | .47 | 122 | 500<br>.52 | 0.0 | 25<br>0.5 | 680 | 1400 | 2.5 | 1.0<br>6.5 |
| DENNIS CR<br>D4 | 50 02<br>117 22 | 17 | .71 | .45 | 182 | 1250<br>.55 | 2.0 | 25<br>2.0 | 930 | 2400 | 3.3 | 1.9<br>5.7 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DERRY CR<br>D2 | 50 46<br>118 33 | 44 | 1.3 | .45 | 300 | 2350<br>.71 | 0.0 | 25<br>22 | 2800 | 5400 | 2.4 | 0.9<br>6.3 |
| DIORITE CR<br>D7 | 49 58<br>115 40 | 53 | 1.3 | .40 | 490 | 4100<br>.72 | 5.0 | 25<br>2.0 | 4600 | 14800 | 4.5 | 2.6<br>7.9 |
| DOG CR<br>D3 | 49 24<br>118 07 | 129 | 1.3 | .40 | 50 | 400<br>.71 | 4.0 | 25<br>35 | 480 | 2000 | 5.8 | 2.4<br>14 |
| DRUMMIE CR<br>D1 | 50 52<br>118 05 | 28 | 1.3 | .45 | 150 | 700<br>.63 | 0.5 | 25<br>7.0 | 1300 | 2000 | 1.9 | 1.0<br>3.6 |
| DUNBAR CR FALLS<br>D5 | 50 47<br>116 21 | 69 | 2.4 | .52 | N/A | N/A<br>N/A | 0.0 | 25<br>7.0 | N/A | N/A | N/A | N/A<br>N/A |
| EAST CR<br>E3 | 50 42<br>116 53 | 73 | 2.9 | .52 | 50 | 500<br>.99 | 15 | 25<br>72 | 1000 | 4900 | 5.1 | 2.0<br>13 |
| EAST CR #1<br>E1 | 50 39<br>117 02 | 175 | 7.0 | .53 | 50 | 500<br>1.4 | 1.0 | 25<br>42 | 2500 | 4800 | 2.0 | 1.1<br>3.8 |
| EAST CR #2<br>E2 | 50 39<br>117 01 | 175 | 7.0 | .53 | 100 | 1150<br>1.4 | 3.0 | 25<br>45 | 5000 | 7700 | 1.6 | 0.9<br>3.0 |
| FALL CR<br>F2 | 50 36<br>118 53 | 15 | .45 | .45 | 500 | 1000<br>.41 | 1.0 | 25<br>1.5 | 1700 | 2200 | 1.7 | 0.9<br>3.2 |
| FALL CR FALLS<br>F3 | 50 36<br>118 54 | 15 | .45 | .45 | N/A | N/A<br>N/A | 2.0 | 25<br>2.5 | N/A | N/A | N/A | N/A<br>N/A |
| FARNHAM FALLS<br>F8 | 50 30<br>116 33 | 78 | 3.1 | .52 | N/A | N/A<br>N/A | 2.0 | 25<br>24 | N/A | N/A | N/A | N/A<br>N/A |
| FENWICK CR<br>F9 | 50 28<br>115 37 | 102 | 2.0 | .50 | 50 | 650<br>.91 | 2.0 | 25<br>40 | 730 | 3300 | 5.1 | 2.9<br>8.8 |
| FERRY CR<br>F1 | 50 15<br>118 39 | N/A | 1.1 | .51 | 150 | 3100<br>.78 | 0.5 | 25<br>1.0 | 1160 | 6000 | 5.7 | 3.8<br>8.5 |
| FITZSTUBBS CR<br>F4 | 50 09<br>117 22 | 251 | 11 | .47 | 60 | 2000<br>2.1 | 0.0 | 25<br>13 | 4900 | 16600 | 4.1 | 2.5<br>6.9 |
| FORSTER CR FALLS<br>F6 | 50 39<br>116 26 | 79 | 3.2 | .52 | N/A | N/A<br>N/A | 8.0 | 25<br>25 | N/A | N/A | N/A | N/A<br>N/A |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FORSTER FALLS<br>F7 | 50 40<br>116 30 | 35 | 1.4 | .52 | N/A | N/A<br>N/A | 13 | 25<br>30 | N/A | N/A | N/A | N/A<br>N/A |
| FOSTHALL CR<br>F5 | 50 22<br>117 57 | 222 | 8.8 | .47 | 60 | 225<br>1.3 | 1.0 | 25<br>34 | 3900 | 4300 | 1.3 | 0.8<br>2.3 |
| GIEGERICH CR<br>G2 | 50 43<br>117 07 | 116 | 4.6 | .53 | 100 | 1100<br>1.2 | 1.0 | 25<br>55 | 3300 | 5900 | 1.9 | 1.0<br>3.5 |
| GILLIS CR<br>G4 | 50 04<br>116 42 | 50 | 1.8 | .50 | 120 | 1200<br>.82 | 12 | 25<br>14 | 1500 | 5300 | 4.0 | 1.7<br>9.0 |
| GOATSKIN CR<br>G1 | 49 43<br>118 39 | 100 | 1.2 | .50 | 100 | 1000<br>.71 | 8.0 | 25<br>60 | 860 | 3600 | 6.0 | 2.8<br>13 |
| GWILLIM CR<br>G3 | 49 45<br>117 28 | 80 | 2.4 | .45 | 240 | 1100<br>.80 | 0.0 | 25<br>1.0 | 4200 | 4100 | 1.2 | 0.6<br>2.4 |
| HADOW CR<br>H4 | 50 40<br>117 48 | 36 | 1.4 | .53 | 400 | 950<br>.59 | 3.5 | 25<br>41 | 4200 | 4000 | 1.0 | 0.6<br>1.7 |
| HALFWAY HOTSPRINGS<br>H5 | 50 29<br>117 51 | 290 | 13 | .47 | 60 | 1300<br>2.0 | 0.0 | 25<br>22 | 5700 | 12800 | 2.7 | 1.6<br>4.5 |
| HALL CR<br>H6 | 50 41<br>117 06 | 44 | 1.8 | .53 | 100 | 850<br>.80 | 0.0 | 25<br>51 | 1200 | 2700 | 2.3 | 1.2<br>4.2 |
| HELLROARER CR<br>H3 | 49 35<br>118 45 | 59 | .71 | .40 | 400 | 1750<br>.50 | 3.5 | 25<br>30 | 2000 | 3800 | 2.7 | 1.2<br>5.8 |
| HIDDEN CR<br>H8 | 49 14<br>117 10 | 70 | 1.5 | .40 | 30 | 250<br>.75 | 1.0 | 25<br>5.0 | 330 | 1400 | 5.9 | 3.6<br>9.7 |
| HOLSTEIN CR<br>H1 | 50 18<br>118 35 | 19 | .29 | .45 | 150 | 1200<br>.41 | 1.5 | 25<br>1.0 | 315 | 1600 | 6.3 | 3.2<br>13 |
| HOPE CR<br>H7 | 50 28<br>117 11 | 23 | .76 | .47 | 240 | 1250<br>.53 | 0.6 | 25<br>24 | 1300 | 2500 | 2.3 | 1.3<br>3.8 |
| HORSETHIEF FALLS<br>H9 | 59 29<br>116 36 | 52 | 1.3 | .55 | N/A | N/A<br>N/A | 2.0 | 25<br>45 | N/A | N/A | N/A | N/A<br>N/A |
| HUNTERS CR<br>H2 | 50 41<br>118 47 | 43 | 1.3 | .45 | 150 | 1900<br>.77 | 3.0 | 25<br>10 | 1400 | 4500 | 4.1 | 1.5<br>11 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IRON CR<br>I1 | 50 43<br>118 36 | 10 | .22 | .47 | 550 | 2000<br>.36 | 0.5 | 25<br>22 | 900 | 2500 | 3.3 | 1.4<br>7.7 |
| JOHN CR<br>J1 | 50 16<br>117 01 | 23 | .62 | .47 | 180 | 1200<br>.51 | 0.0 | 25<br>4.5 | 800 | 2000 | 3.0 | 1.9<br>4.5 |
| KAIN CR<br>K3 | 50 51<br>116 35 | 34 | .95 | .52 | 250 | 1100<br>.56 | 2.0 | 25<br>16 | 1700 | 2700 | 1.7 | 0.9<br>3.5 |
| KELLIE CR<br>K1 | 50 55<br>117 34 | 46 | 1.8 | .53 | 250 | 1150<br>.71 | 11 | 25<br>65 | 3100 | 4900 | 1.7 | 1.0<br>2.8 |
| KUSHANAX CR<br>K2 | 50 16<br>117 46 | 330 | 15 | .47 | 60 | 900<br>2.0 | 0.0 | 25<br>0.0 | 6300 | 9000 | 1.7 | 1.2<br>2.6 |
| LADYBIRD CR<br>L6 | 49 25<br>117 40 | 156 | 2.0 | .40 | 120 | 600<br>.76 | 1.0 | 25<br>2.5 | 1780 | 2300 | 1.8 | 1.0<br>3.4 |
| LAIDLAW CR<br>L5 | 50 52<br>117 14 | 49 | 2.2 | .53 | 150 | 1400<br>.88 | 1.0 | 25<br>73 | 2370 | 5000 | 2.2 | 1.2<br>4.3 |
| LASCA CR<br>L7 | 49 36<br>117 09 | 64 | 1.5 | .45 | 300 | 2100<br>.72 | 0.0 | 25<br>1.0 | 3200 | 5400 | 2.1 | 1.1<br>4.2 |
| LATEWHOS CR<br>L3 | 50 27<br>118 43 | 43 | .65 | .45 | 450 | 2600<br>.51 | 1.0 | 25<br>8.0 | 2100 | 4300 | 2.6 | 1.1<br>6.3 |
| LEGERWOOD CR<br>L2 | 50 58<br>118 46 | 12 | .53 | .45 | 250 | 1300<br>.47 | 0.0 | 25<br>1.5 | 950 | 1900 | 2.6 | 1.5<br>4.3 |
| LEXINGTON CR<br>L4 | 50 50<br>117 37 | 15 | .55 | .53 | 450 | 1700<br>.45 | 2.5 | 25<br>58 | 1780 | 3100 | 1.9 | 1.1<br>3.1 |
| LITTLE GLACIER CR<br>L8 | 50 26<br>116 55 | 36 | 1.3 | .50 | 60 | 600<br>.72 | 0.0 | 25<br>26 | 550 | 1900 | 3.8 | 1.7<br>8.7 |
| LOFTUS CR<br>L1 | 50 56<br>118 49 | 17 | .75 | .45 | 250 | 1000<br>.51 | 0.0 | 25<br>0.5 | 1350 | 2000 | 1.8 | 1.1<br>3.1 |
| LOKI CR<br>L11 | 49 50<br>116 51 | 28 | .87 | .45 | 430 | 2400<br>.57 | 2.5 | 25<br>14 | 2600 | 5400 | 2.6 | 1.3<br>4.9 |
| LOST LEDGE CR<br>L9 | 50 06<br>116 56 | 14 | .28 | .47 | 430 | 1700<br>.36 | 0.0 | 25<br>0.5 | 860 | 1900 | 2.6 | 1.0<br>6.6 |

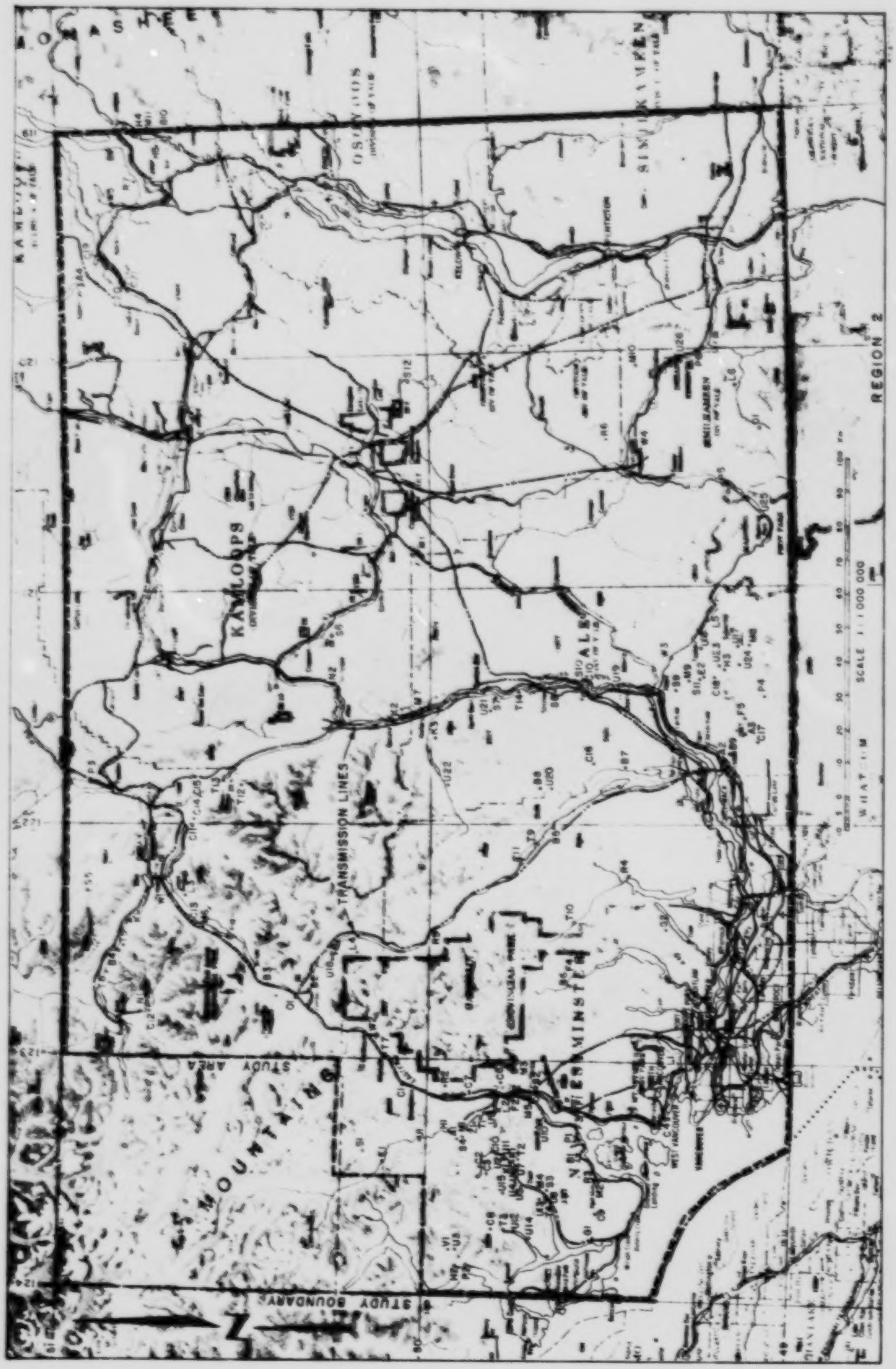
| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LUXOR CR<br>L10 | 50 46<br>116 10 | 81 | .97 | .52 | 100 | 1400<br>.70 | 3.0 | 25<br>3.0 | 700 | 3400 | 5.3 | 2.0<br>14 |
| MABEL CR<br>M2 | 50 37<br>118 36 | 10 | .22 | .47 | 250 | 800<br>.36 | 6.0 | 25<br>11 | 420 | 1800 | 5.2 | 2.2<br>12 |
| McDONALD CR<br>M7 | 50 34<br>116 25 | 50 | 1.8 | .52 | 250 | 1100<br>.71 | 2.0 | 25<br>36 | 3100 | 3500 | 1.2 | 0.5<br>3.0 |
| McDOUGAL CR<br>M4 | 50 58<br>117 37 | 85 | 3.4 | .53 | 150 | 850<br>.95 | 16 | 25<br>80 | 3600 | 6400 | 1.9 | 1.1<br>3.2 |
| MEADOW CR<br>M5 | 50 18<br>117 03 | 23 | .62 | .47 | 180 | 1300<br>.52 | 0.0 | 25<br>4.0 | 800 | 2100 | 3.1 | 2.1<br>4.8 |
| MENHINICK CR<br>M3 | 50 49<br>117 39 | 17 | .60 | .53 | 200 | 900<br>.47 | 0.5 | 25<br>53 | 860 | 1900 | 2.3 | 1.3<br>3.9 |
| MIDGE CR<br>M8 | 49 22<br>116 52 | 243 | 5.6 | .55 | 30 | 1000<br>1.6 | 6.5 | 25<br>33 | 1200 | 7700 | 6.4 | 3.5<br>12 |
| MITCHELL R FALLS<br>M9 | 50 48<br>115 42 | 74 | 1.8 | .50 | N/A | N/A<br>N/A | 23 | 25<br>45 | N/A | N/A | N/A | N/A<br>N/A |
| MITCHELL R RAPIDS<br>M10 | 50 47<br>115 41 | 110 | 2.6 | .50 | N/A | N/A<br>N/A | 20 | 25<br>40 | N/A | N/A | N/A | N/A<br>N/A |
| MULVEHILL CR<br>M1 | 50 51<br>118 07 | 42 | 1.9 | .45 | 150 | 550<br>.70 | 0.0 | 25<br>17 | 2000 | 2100 | 1.3 | 0.7<br>2.6 |
| MURPHY CR<br>M6 | 49 10<br>117 44 | 73 | .95 | .40 | 60 | 500<br>.63 | 0.6 | 25<br>2.5 | 410 | 1400 | 4.9 | 2.7<br>9.0 |
| NEMO CR<br>N1 | 49 55<br>117 25 | 68 | 2.0 | .45 | 490 | 3300<br>.81 | 3.5 | 25<br>3.0 | 7100 | 15500 | 2.7 | 1.4<br>5.3 |
| NEXT CR<br>N2 | 49 18<br>116 45 | 155 | 3.6 | .55 | 120 | 1100<br>1.1 | 1.0 | 25<br>25 | 3000 | 4900 | 1.7 | 0.9<br>3.0 |
| OCTOPUS CR<br>O2 | 49 45<br>118 06 | 45 | .68 | .40 | 150 | 650<br>.49 | 1.0 | 138<br>6.0 | 730 | 1700 | 3.2 | 1.7<br>6.1 |
| OUTLET CR<br>O1 | 50 20<br>118 30 | 40 | .60 | .45 | 150 | 1400<br>.54 | 1.5 | 25<br>3.0 | 640 | 2400 | 5.0 | 2.4<br>9.2 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PALLISER FALLS #1<br>P5 | 50 32<br>115 36 | 277 | 6.7 | .50 | N/A | N/A<br>N/A | 2.0 | 25<br>53 | N/A | N/A | N/A | N/A<br>N/A |
| PALLISER FALLS #2<br>P6 | 50 32<br>115 28 | 358 | 8.6 | .50 | N/A | N/A<br>N/A | 8.0 | 25<br>63 | N/A | N/A | N/A | N/A<br>N/A |
| PAYNE CR<br>P2 | 50 37<br>117 51 | 54 | 1.6 | .53 | 100 | 400<br>.67 | 0.0 | 25<br>45 | 1100 | 1800 | 1.6 | 0.9<br>2.9 |
| POOL CR<br>P1 | 50 47<br>117 38 | 65 | 2.5 | .53 | 350 | 3000<br>.91 | 0.0 | 25<br>51 | 6200 | 12300 | 2.1 | 1.3<br>3.5 |
| POPLAR CR<br>P3 | 50 26<br>117 08 | 128 | 4.2 | .47 | 120 | 2700<br>1.3 | 0.0 | 25<br>17 | 3600 | 12000 | 4.0 | 2.5<br>6.3 |
| POWDER CR<br>P4 | 49 53<br>116 51 | 45 | 1.4 | .45 | 370 | 2500<br>.70 | 2.0 | 25<br>23 | 3600 | 7300 | 2.5 | 1.3<br>4.8 |
| QUARRIE CR<br>Q1 | 50 16<br>114 59 | 59 | 1.2 | .50 | 50 | 550<br>.72 | 1.0 | 25<br>12 | 420 | 1900 | 5.1 | 2.9<br>8.9 |
| RAPID CR<br>R2 | 50 27<br>117 10 | 35 | 1.2 | .47 | 300 | 2400<br>.67 | 0.0 | 25<br>21 | 2500 | 5200 | 2.5 | 1.6<br>3.9 |
| RIOULX CR<br>R1 | 50 17<br>118 05 | 53 | .90 | .45 | 200 | 2000<br>.64 | 6.0 | 25<br>30 | 1290 | 4500 | 4.4 | 1.8<br>11 |
| SANCA CR<br>S13 | 49 23<br>116 43 | 100 | 2.3 | .55 | 120 | 1000<br>.88 | 3.0 | 25<br>25 | 2000 | 4000 | 2.1 | 1.1<br>3.9 |
| SCHROEDER CR<br>S11 | 50 02<br>116 53 | 32 | .64 | .47 | 300 | 2300<br>.53 | 0.0 | 25<br>0.5 | 1400 | 3400 | 3.0 | 1.2<br>7.7 |
| SEPTET CR<br>S10 | 50 48<br>116 41 | 40 | 1.4 | .52 | 150 | 950<br>.69 | 2.0 | 25<br>34 | 1500 | 2810 | 2.0 | 0.7<br>6.3 |
| SHANNON CR<br>S9 | 50 05<br>117 29 | 33 | 1.5 | .47 | 180 | 1700<br>.76 | 0.0 | 25<br>2.0 | 1900 | 3800 | 2.3 | 1.4<br>3.9 |
| SHAW CR<br>S14 | 49 15<br>116 43 | 48 | 1.1 | .55 | 240 | 1000<br>.59 | 1.0 | 25<br>21 | 1900 | 2500 | 1.3 | 0.7<br>2.5 |
| SHUSWAP R BRENDA F<br>S1 | 50 21<br>118 32 | N/A | 39 | .45 | N/A | N/A<br>N/A | 0.0 | 25<br>0.0 | N/A | N/A | N/A | N/A<br>N/A |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SICAMOUS CR<br>S6 | 50 48<br>118 58 | 64 | 1.6 | .45 | 200 | 1400<br>.74 | 0.0 | 25<br>0.0 | 2300 | 3300 | 1.8 | 0.5<br>6.2 |
| SKOOKUMCHUCK F #2<br>S16 | 49 58<br>116 08 | 133 | 2.4 | .40 | N/A | N/A<br>N/A | 1.0 | 25<br>42 | N/A | N/A | N/A | N/A<br>N/A |
| SKOOKUMCHUCK F #1<br>S15 | 49 58<br>116 07 | 141 | 2.5 | .40 | N/A | N/A<br>N/A | 1.0 | 25<br>41 | N/A | N/A | N/A | N/A<br>N/A |
| SLEWISKIN CR<br>S8 | 50 08<br>117 47 | 76 | 3.4 | .45 | 60 | 1200<br>1.2 | 0.0 | 25<br>2.0 | 1500 | 5400 | 4.6 | 2.7<br>7.7 |
| SMYTH CR<br>S3 | 50 32<br>118 43 | 16 | .29 | .45 | 600 | 2000<br>.36 | 0.0 | 25<br>15 | 1200 | 2600 | 2.6 | 0.9<br>7.6 |
| SOUTH CRANBERRY CR<br>S4 | 50 46<br>118 06 | 59 | 2.7 | .52 | 200 | 900<br>.83 | 3.0 | 25<br>29 | 3800 | 4100 | 1.1 | 0.6<br>2.2 |
| SOWSAP CR<br>S2 | 50 26<br>118 46 | 52 | .42 | .45 | 200 | 2100<br>.49 | 3.0 | 25<br>3.5 | 600 | 3100 | 6.4 | 1.8<br>23 |
| SPECTRUM CR FALLS<br>S5 | 50 29<br>118 27 | 78 | 2.0 | .50 | N/A | N/A<br>N/A | 0.2 | 25<br>18 | N/A | N/A | N/A | N/A<br>N/A |
| STEWART CR<br>S7 | 49 07<br>118 15 | 18 | .19 | .40 | 250 | 1050<br>.31 | 6.0 | 25<br>8.0 | 340 | 1700 | 6.8 | 2.8<br>16 |
| STOCKDALE CR<br>S12 | 50 35<br>116 35 | 66 | 2.6 | .52 | 50 | 700<br>1.0 | 9.0 | 25<br>38 | 950 | 4500 | 5.2 | 2.0<br>13 |
| TAM O'SHANTER CR<br>T5 | 49 48<br>116 51 | 31 | .96 | .45 | 490 | 3000<br>.60 | 3.5 | 25<br>10 | 3400 | 7800 | 2.9 | 1.5<br>5.6 |
| TEMPLETON CR<br>T4 | 50 48<br>116 29 | 29 | 1.0 | .52 | 250 | 1700<br>.62 | 4.0 | 25<br>21 | 1800 | 3900 | 2.3 | 0.7<br>7.1 |
| TENDERFOOT CR<br>T3 | 50 28<br>117 13 | 45 | 1.5 | .47 | 240 | 2500<br>.78 | 0.0 | 25<br>28 | 2600 | 6100 | 2.8 | 1.7<br>4.9 |
| TOWN CR<br>T2 | 50 46<br>117 45 | 14 | .49 | .53 | 400 | 1400<br>.44 | 2.0 | 25<br>44 | 1450 | 2600 | 1.9 | 1.1<br>3.2 |
| TSUIUS CR<br>T1 | 50 37<br>118 40 | 208 | 5.0 | .47 | 150 | 1650<br>1.2 | 4.0 | 25<br>7.0 | 5300 | 8600 | 1.9 | 0.9<br>4.3 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNNAMED CR<br>U10 | 50 21<br>116 51 | 16 | .32 | .55 | 430 | 2000<br>.41 | 0.5 | 25<br>15 | 1000 | 2400 | 2.4 | 1.3<br>4.6 |
| UNNAMED CR<br>U2 | 50 55<br>118 07 | 19 | .85 | .45 | 250 | 1150<br>.54 | 0.5 | 25<br>1.0 | 1500 | 2300 | 1.9 | 1.0<br>3.7 |
| UNNAMED CR<br>U13 | 49 59<br>116 03 | 39.5 | .75 | .40 | 300 | 1100<br>.50 | 1.5 | 25<br>37 | 1600 | 2500 | 2.2 | 1.0<br>4.9 |
| UNNAMED CR<br>U8 | 50 09<br>116 38 | 23 | .46 | .50 | 240 | 1000<br>.44 | 4.5 | 25<br>21 | 820 | 2300 | 3.1 | 1.7<br>5.9 |
| UNNAMED CR<br>U11 | 50 21<br>116 48 | 15 | .30 | .50 | 240 | 900<br>.36 | 0.5 | 25<br>19 | 530 | 1330 | 2.9 | 1.5<br>5.3 |
| UNNAMED CR<br>U12 | 49 59<br>116 00 | 8.2 | .16 | .40 | 560 | 1550<br>.31 | 2.0 | 25<br>33 | 660 | 1930 | 4.2 | 1.8<br>9.3 |
| UNNAMED CR<br>U6 | 50 20<br>116 51 | 14 | .28 | .50 | 300 | 1150<br>.36 | 0.5 | 25<br>14 | 620 | 1500 | 2.6 | 1.4<br>4.8 |
| UNNAMED CR<br>U9 | 50 06<br>116 46 | 9 | .18 | .50 | 550 | 1650<br>.31 | 0.0 | 25<br>8.0 | 730 | 1600 | 2.5 | 1.4<br>4.5 |
| UNNAMED CR<br>U4 | 50 58<br>118 36 | 10 | .50 | .45 | 300 | 700<br>.40 | 0.0 | 25<br>7.0 | 1100 | 1400 | 1.6 | 0.8<br>2.9 |
| UNNAMED CR FALLS<br>U1 | 50 58<br>118 36 | 11 | .55 | .45 | N/A | N/A<br>N/A | 0.0 | 25<br>7.0 | N/A | N/A | N/A | N/A<br>N/A |
| UNNAMED CR<br>U7 | 50 59<br>116 45 | 24 | .72 | .52 | 400 | 1100<br>.47 | 2.0 | 25<br>34 | 2000 | 2600 | 1.4 | 0.7<br>2.7 |
| UNNAMED CR<br>U3 | 50 57<br>118 24 | 24 | 1.2 | .45 | 300 | 1100<br>.59 | 0.0 | 25<br>6.0 | 2500 | 2600 | 1.3 | 0.7<br>2.4 |
| UNNAMED CR<br>U5 | 50 07<br>116 44 | 11 | .22 | .50 | 490 | 1400<br>.30 | 0.5 | 25<br>13 | 770 | 1500 | 2.1 | 1.1<br>4.0 |
| VAN HOUTEN CR<br>V2 | 49 40<br>118 07 | 38 | .57 | .40 | 150 | 700<br>.47 | 4.0 | 138<br>16 | 600 | 2000 | 4.5 | 2.4<br>8.6 |
| VICTOR CR<br>V1 | 50 57<br>118 24 | 10 | .50 | .45 | 300 | 550<br>.40 | 0.0 | 25<br>6.0 | 1100 | 1300 | 1.5 | 0.8<br>2.7 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOWELL CR<br>V3 | 50 53<br>116 52 | 132 | 5.9 | .52 | 50 | 800<br>1.4 | 6.0 | 25<br>50 | 2100 | 6600 | 3.4 | 1.4<br>7.9 |
| WAP CR FALLS<br>W1 | 50 54<br>118 29 | 66 | 3.3 | .45 | N/A | N/A<br>N/A | 0.5 | 25<br>14 | N/A | N/A | N/A | N/A<br>N/A |
| WARREN CR<br>W6 | 50 58<br>116 42 | 47 | 1.4 | .52 | 550 | 3400<br>.69 | 6.0 | 25<br>30 | 5500 | 12700 | 2.5 | 1.3<br>4.8 |
| WEE SANDY CR<br>W4 | 50 00<br>117 25 | 59 | 1.8 | .47 | 180 | 900<br>.72 | 0.0 | 25<br>10 | 2300 | 2900 | 1.5 | 0.8<br>2.8 |
| WHATSHAN L DAM & F<br>W2 | 49 54<br>118 07 | 590 | 7.0 | .40 | N/A | N/A<br>N/A | 0.6 | 60<br>1.0 | N/A | N/A | N/A | N/A<br>N/A |
| WILSON CR FALLS<br>W3 | 50 08<br>117 20 | 205 | 9.2 | .47 | 60 | 550<br>1.5 | 1.0 | 25<br>11 | 3900 | 5500 | 1.7 | 1.0<br>2.8 |
| WILSON CR<br>W8 | 49 35<br>116 52 | 25 | .58 | .55 | 609 | 2700<br>.47 | 3.0 | 25<br>12 | 2500 | 6000 | 2.5 | 1.1<br>5.4 |
| WOODBURY CR<br>W7 | 49 48<br>116 57 | 83 | 1.9 | .55 | 300 | 3900<br>.90 | 0.0 | 25<br>6.0 | 4190 | 13900 | 3.4 | 1.6<br>7.6 |
| WRAGGE CR<br>W5 | 50 04<br>117 28 | 25 | 1.1 | .45 | 244 | 1800<br>.66 | 2.0 | 25<br>2.0 | 1990 | 3700 | 2.4 | 1.4<br>4.0 |
| YARD CR FALLS<br>Y2 | 50 53<br>118 48 | 122 | 3.1 | .45 | N/A | N/A<br>N/A | 1.0 | 25<br>2.0 | N/A | N/A | N/A | N/A<br>N/A |
| YARD CR<br>Y1 | 50 54<br>118 48 | 122 | 3.1 | .45 | 150 | 1550<br>1.0 | 0.0 | 25<br>0.0 | 3290 | 5700 | 2.2 | 0.7<br>7.4 |


N
STUDY BOUNDARY
STUDY AREA
COAST MOUNTAINS
TRANSMISSION LINES
KAMLOOPS
YALE
NEW WESTMINSTER
OSOYOOS
SIMILKAMEEN
KELOWNA
PENTICTON
REGION 2
SCALE 1:1 000 000

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADAMS R RAPIDS<br>A4 | 50 56<br>119 39 | N/A | 71 | .60 | N/A | N/A<br>N/A | 0.0 | 25<br>0.0 | N/A | N/A | N/A | N/A<br>N/A |
| AIRPLANE CR<br>A3 | 49 08<br>121 37 | 16 | .90 | .63 | 300 | 1400<br>.56 | 2.5 | 25<br>7.0 | 2000 | 2800 | 1.3 | 0.8<br>2.1 |
| ANDERSON CR<br>A2 | 49 11<br>121 43 | 4 | .21 | .63 | 850 | 1500<br>.31 | 3.0 | 25<br>5.0 | 1300 | 2700 | 1.8 | 1.1<br>3.0 |
| ASHLU CR<br>A1 | 49 55<br>123 20 | 310 | 23 | .55 | 120 | 1400<br>2.2 | 2.0 | 230<br>5.0 | 20500 | 20000 | 1.0 | 0.6<br>1.7 |
| BASTION CR<br>B11 | 50 51<br>119 05 | 12 | .24 | .45 | 300 | 1000<br>.36 | 0.0 | 25<br>17 | 500 | 1200 | 2.8 | 1.1<br>7.3 |
| BEAR CR<br>B7 | 49 28<br>121 46 | 29 | 1.6 | .60 | 365 | 2100<br>.71 | 0.0 | 25<br>20 | 4100 | 6200 | 1.4 | 0.8<br>2.5 |
| BIG SILVER CR<br>B8 | 49 42<br>121 51 | 295 | 13 | .55 | 100 | 1600<br>1.9 | 0.0 | 25<br>0.0 | 9500 | 15000 | 1.6 | 0.7<br>3.9 |
| BIRKENHEAD R #1<br>B2 | 50 20<br>122 43 | 590 | 23 | .63 | 30 | 200<br>2.0 | 1.0 | 25<br>1.0 | 5100 | 7000 | 1.2 | 0.8<br>1.8 |
| BIRKENHEAD R #2<br>B3 | 50 27<br>122 41 | 380 | 15 | .63 | 61 | 750<br>2.0 | 2.0 | 25<br>2.0 | 6700 | 9000 | 1.2 | 0.8<br>1.8 |
| BLURTON CR<br>B10 | 50 41<br>119 02 | 19 | .48 | .45 | 400 | 1600<br>.44 | 1.0 | 25<br>1.0 | 1400 | 2400 | 2.1 | 1.3<br>3.5 |
| BOBB CR<br>B4 | 50 51<br>122 33 | 40 | .80 | .52 | 300 | 1400<br>.53 | 10 | 60<br>22 | 1700 | 4100 | 2.6 | 1.2<br>5.6 |
| BOISE CR<br>B6 | 49 37<br>122 41 | 59 | 4.7 | .55 | 275 | 2200<br>1.1 | 5.0 | 25<br>50 | 9300 | 14300 | 1.6 | 0.8<br>3.4 |
| BOX CANYON CR<br>B1 | 49 35<br>123 24 | 6 | .76 | .55 | 400 | 1400<br>.50 | 2.0 | 138<br>2.0 | 2100 | 3000 | 1.4 | 0.9<br>2.2 |
| BREMNER CR<br>B5 | 49 40<br>122 01 | 39 | 3.1 | .55 | 60 | 200<br>.83 | 0.5 | 25<br>7.0 | 1400 | 2300 | 1.8 | 0.8<br>3.7 |
| BRIDAL CR @ FALLS<br>B9 | 49 10<br>121 42 | 3 | .16 | .63 | N/A | N/A<br>N/A | 1.0 | 25<br>4.0 | N/A | N/A | N/A | N/A<br>N/A |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CADWALLADER CR<br>C12 | 50 46<br>122 48 | 172 | 4.8 | .52 | 50 | 600<br>1.2 | 2.0 | 25<br>0.5 | 1700 | 4400 | 2.8 | 1.0<br>7.8 |
| CALLAGHAN CR<br>C1 | 50 04<br>123 06 | 200 | 16 | .60 | 60 | 1400<br>2.2 | 1.0 | 230<br>2.0 | 7000 | 15200 | 2.1 | 1.2<br>3.5 |
| CANTELON / YOLA CR<br>C18 | 49 13<br>121 23 | 66 | 3.0 | .63 | 105 | 2000<br>1.1 | 2.0 | 25<br>22 | 2200 | 8000 | 3.2 | 1.9<br>5.4 |
| CAPILANO R DAM<br>C5 | 49 21<br>123 06 | 190 | N/A | .55 | 100 | N/A<br>N/A | 0.0 | 25<br>0.0 | N/A | N/A | N/A | N/A<br>N/A |
| CAYOOSH CR #1<br>C11 | 50 39<br>122 01 | 835 | 20 | .53 | 50 | 900<br>2.3 | 3.0 | 25<br>7.0 | 7000 | 13200 | 2.0 | 1.3<br>3.0 |
| CAYOOSH CR FALLS<br>C14 | 50 39<br>121 59 | 887 | 21 | .53 | N/A | N/A<br>N/A | 1.0 | 25<br>4.0 | N/A | N/A | N/A | N/A<br>N/A |
| CAYOOSH CR #2<br>C15 | 50 39<br>121 59 | 887 | 21 | .53 | 30 | 800<br>2.5 | 1.0 | 25<br>4.0 | 4620 | 12000 | 2.8 | 1.9<br>4.2 |
| CHAPMAN CR FALLS<br>C9 | 49 32<br>123 38 | 33 | 2.4 | .55 | N/A | N/A<br>N/A | 1.0 | 25<br>11 | N/A | N/A | N/A | N/A<br>N/A |
| CHASE CR<br>C20 | 50 49<br>119 41 | 20 | .99 | .45 | 100 | 500<br>.58 | 0.0 | 25<br>0.0 | 700 | 1400 | 2.5 | 1.0<br>5.9 |
| CHEEKYE R<br>C6 | 49 48<br>123 06 | 24 | 1.7 | .55 | 120 | 1200<br>.81 | 4.0 | 25<br>7.0 | 1400 | 3900 | 2.7 | 1.7<br>4.2 |
| CHICKWAT CR<br>C8 | 49 49<br>123 43 | 46 | 3.7 | .55 | 180 | 1050<br>.98 | 2.0 | 25<br>27 | 4800 | 5500 | 1.2 | 0.7<br>1.9 |
| CHIPMUNK CR<br>C17 | 49 06<br>121 39 | 37 | 2.0 | .63 | 455 | 3000<br>.80 | 2.0 | 25<br>3.0 | 6500 | 10800 | 1.5 | 0.9<br>2.4 |
| CLOWHOM R<br>C2 | 49 51<br>123 27 | 48 | 3.6 | .55 | 120 | 1000<br>1.0 | 12 | 138<br>25 | 3100 | 6600 | 2.2 | 1.3<br>3.5 |
| CLOWHOM R<br>C3 | 49 50<br>123 29 | 22 | 1.7 | .55 | 320 | 600<br>.60 | 14 | 138<br>27 | 3800 | 4800 | 1.3 | 0.8<br>2.1 |
| CLOWHOM R<br>C10 | 49 49<br>123 23 | 104 | 7.8 | .55 | 60 | 400<br>1.3 | 6.0 | 138<br>19 | 3400 | 5500 | 1.7 | 1.0<br>2.8 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COGBURN CR<br>C16 | 49 33<br>121 45 | 130 | 5.9 | .60 | 100 | 1050<br>1.3 | 0.0 | 25<br>35 | 4200 | 6500 | 1.5 | 0.6<br>3.5 |
| CONNEL CR<br>C13 | 50 39<br>122 25 | 50 | .65 | .52 | 950 | 3800<br>.48 | 5.0 | 60<br>0.5 | 4400 | 12700 | 3.1 | 1.5<br>6.6 |
| CORNING CR<br>C19 | 50 54<br>119 32 | 26 | .52 | .45 | 100 | 700<br>.49 | 0.0 | 25<br>0.0 | 370 | 1300 | 4.3 | 1.6<br>11 |
| CULLITON CR<br>C7 | 49 53<br>123 09 | 35 | 2.6 | .55 | 370 | 3500<br>.94 | 2.0 | 25<br>15 | 6800 | 14000 | 2.1 | 1.4<br>3.3 |
| CYPRESS CR<br>C4 | 49 20<br>123 14 | 13 | 1.3 | .55 | 105 | 825<br>.70 | 0.0 | 25<br>0.0 | 1000 | 1800 | 1.9 | 1.1<br>3.2 |
| DURUISSEAU CR<br>D1 | 49 05<br>120 21 | 36 | .29 | .45 | 250 | 1600<br>.41 | 2.0 | 25<br>24 | 540 | 2100 | 5.0 | 2.5<br>10 |
| EATON CR<br>E2 | 49 15<br>121 23 | 7 | .30 | .63 | 850 | 2150<br>.36 | 3.0 | 25<br>16 | 1900 | 4300 | 2.0 | 1.2<br>3.5 |
| ELAHO CR<br>E1 | 50 07<br>123 26 | 1200 | 108 | .60 | 30 | 650<br>4.2 | 1.0 | 230<br>27 | 19400 | 30000 | 1.5 | 0.9<br>2.5 |
| FISH HATCHERY CR<br>F4 | 49 36<br>122 38 | 13.5 | 1.1 | .55 | 670 | 1600<br>.53 | 3.0 | 25<br>50 | 5200 | 6600 | 1.3 | 0.6<br>2.8 |
| FOLEY CR<br>F5 | 49 08<br>121 33 | 17 | .85 | .60 | 240 | 2800<br>.64 | 4.0 | 25<br>14 | 1500 | 4900 | 3.1 | 1.9<br>5.3 |
| FRIES CR<br>F2 | 49 45<br>123 09 | 23 | 1.6 | .55 | 180 | 1100<br>.72 | 4.0 | 25<br>3.0 | 2000 | 3200 | 1.6 | 1.0<br>2.6 |
| FURRY CR FALLS<br>F1 | 49 35<br>123 12 | 38 | 2.6 | .57 | N/A | N/A<br>N/A | 2.0 | 25<br>6.0 | N/A | N/A | N/A | N/A<br>N/A |
| FURRY CR<br>F3 | 49 35<br>123 13 | 52 | 3.6 | .57 | 230 | 1600<br>1.0 | 2.0 | 25<br>6.0 | 5800 | 6200 | 1.1 | 0.6<br>1.8 |
| GOLD CR<br>G2 | 49 21<br>122 27 | 75 | 5.3 | .55 | 50 | 250<br>1.1 | 3.0 | 25<br>16 | 1900 | 3100 | 1.7 | 0.6<br>4.5 |
| GRAY CR<br>G1 | 49 32<br>123 45 | 52 | 3.6 | .55 | 95 | 700<br>1.0 | 2.0 | 25<br>8.0 | 2490 | 4000 | 1.7 | 1.0<br>2.8 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HICKS CR<br>H3 | 49 11<br>121 21 | 18 | .81 | .63 | 120 | 900<br>.58 | 2.0 | 25<br>25 | 700 | 2200 | 2.8 | 1.7<br>4.6 |
| HIGH CR<br>H2 | 49 55<br>123 52 | 31 | 2.2 | .55 | 210 | 1000<br>.77 | 2.0 | 25<br>21 | 3300 | 3710 | 1.2 | 0.6<br>2.1 |
| HIGH FALLS CR<br>H1 | 49 56<br>123 18 | 27 | 2.0 | .55 | 520 | 1700<br>.71 | 3.0 | 230<br>1.0 | 7500 | 7700 | 1.1 | 0.6<br>1.7 |
| HILLS CR<br>H5 | 50 43<br>119 04 | 34 | .68 | .45 | 250 | 1250<br>.51 | 1.0 | 25<br>3.0 | 1200 | 2300 | 2.3 | 0.9<br>6.1 |
| HUMMING BIRD CR<br>H4 | 50 46<br>119 00 | 15 | .30 | .45 | 250 | 750<br>.36 | 0.0 | 25<br>1.0 | 550 | 1100 | 2.5 | 1.4<br>4.4 |
| JOFFRE CR<br>J1 | 49 18<br>122 35 | 95 | 3.8 | .57 | 190 | 900<br>.96 | 1.0 | 25<br>10 | 5200 | 4800 | 0.9 | 0.5<br>1.6 |
| KEARY CR<br>K1 | 50 49<br>122 25 | 41 | .60 | .52 | 400 | 2800<br>.52 | 10 | 60<br>12 | 1700 | 6000 | 3.7 | 1.5<br>9.0 |
| KOOKIPI CR<br>K3 | 49 59<br>121 38 | 116 | 4.6 | .47 | 350 | 2700<br>1.1 | 7.0 | 25<br>12 | 11600 | 20000 | 2.0 | 0.8<br>5.4 |
| KWOIEK CR<br>K2 | 50 07<br>121 35 | 247 | 7.4 | .60 | 350 | 3500<br>1.4 | 6.0 | 25<br>7.0 | 18600 | 35000 | 1.8 | 0.9<br>3.5 |
| LAFORGUE CR<br>L5 | 49 14<br>121 09 | 14 | .62 | .60 | 300 | 1200<br>.47 | 2.0 | 25<br>27 | 1300 | 2200 | 1.6 | 0.9<br>2.7 |
| LAKE LOVELY WATER<br>L2 | 49 48<br>123 13 | 10 | .75 | .60 | 1100 | 3400<br>.48 | 7.0 | 25<br>9.0 | 5900 | 12400 | 2.0 | 1.2<br>3.2 |
| LAKEVIEW CR<br>L6 | 49 09<br>120 10 | 40 | .32 | .45 | 550 | 2900<br>.41 | 4.0 | 25<br>20 | 1300 | 4300 | 4.1 | 2.2<br>7.8 |
| LIZZIE CR<br>L4 | 50 12<br>122 28 | 70 | 3.5 | .57 | 230 | 2000<br>1.0 | 3.0 | 138<br>1.0 | 5700 | 9400 | 1.6 | 0.9<br>3.0 |
| LOST VALLEY CR<br>L3 | 50 40<br>122 18 | 94 | .94 | .52 | 350 | 1050<br>.52 | 2.0 | 60<br>6.0 | 2300 | 2900 | 1.3 | 0.7<br>2.5 |
| LYNN CR<br>L1 | 49 21<br>123 01 | 40 | 4.0 | .55 | 75 | 1800<br>1.3 | 0.0 | 25<br>0.0 | 2100 | 6400 | 3.1 | 1.9<br>5.0 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAIMEN CR<br>M9 | 49 17<br>121 24 | 9 | .39 | .60 | 610 | 3150<br>.44 | 4.0 | 25<br>11 | 1700 | 5400 | 2.9 | 1.7<br>5.0 |
| MAMQUAM CR<br>M3 | 49 43<br>123 04 | 258 | 22 | .57 | 190 | 825<br>1.8 | 2.0 | 25<br>6.0 | 28700 | 14100 | 0.8 | 0.6<br>1.5 |
| MARA CR<br>M11 | 50 46<br>119 00 | 23 | .46 | .45 | 250 | 1000<br>.44 | 0.0 | 25<br>1.0 | 850 | 1600 | 2.4 | 1.4<br>4.3 |
| MASELPANIK CR<br>M8 | 49 07<br>121 15 | 52 | 2.3 | .63 | 300 | 2500<br>.88 | 3.0 | 25<br>37 | 5100 | 9400 | 1.7 | 1.0<br>2.8 |
| MAWBY CR<br>M1 | 49 53<br>123 18 | 9 | .65 | .55 | 580 | 1150<br>.44 | 5.0 | 230<br>2.0 | 2700 | 3600 | 1.3 | 0.8<br>2.2 |
| McGILLIVARY CR<br>M6 | 50 37<br>122 26 | 77 | 1.2 | .52 | 350 | 1300<br>.59 | 2.0 | 60<br>1.0 | 2900 | 3800 | 1.4 | 0.6<br>3.5 |
| McNAIR CR<br>M2 | 49 31<br>123 30 | 18 | 2.1 | .55 | 180 | 1600<br>.86 | 2.0 | 25<br>1.0 | 2800 | 5200 | 1.9 | 1.2<br>3.1 |
| McNULTY CR<br>M10 | 49 25<br>120 05 | 200 | 1.3 | .40 | 250 | 1900<br>.69 | 2.5 | 25<br>10 | 2200 | 4100 | 2.6 | 1.3<br>5.1 |
| MISERY CR FALLS<br>M4 | 49 40<br>123 35 | 60 | 4.8 | .55 | N/A | N/A<br>N/A | 1.0 | 138<br>6.0 | N/A | N/A | N/A | N/A<br>N/A |
| MONMOUTH CR<br>M5 | 49 43<br>123 11 | 8 | .59 | .55 | 470 | 1000<br>.44 | 5.0 | 25<br>3.0 | 2040 | 2800 | 1.4 | 0.8<br>2.3 |
| MOWHOKAM CR<br>M7 | 50 02<br>121 31 | 118 | 1.4 | .50 | 100 | 1000<br>.76 | 3.0 | 25<br>3.0 | 1000 | 3100 | 3.4 | 1.5<br>7.7 |
| NICOAMEN CR<br>N2 | 50 16<br>121 24 | 153 | 1.5 | .50 | 200 | 600<br>.63 | 2.0 | 25<br>10 | 2200 | 2400 | 1.2 | 0.5<br>3.1 |
| NOEL CR<br>N1 | 50 46<br>122 48 | 98 | 3.2 | .52 | 50 | 400<br>.99 | 3.0 | 60<br>2.0 | 1160 | 3100 | 2.9 | 1.2<br>6.9 |
| OWL CR<br>O1 | 50 22<br>122 44 | 55 | 2.2 | .62 | 150 | 900<br>.81 | 3.0 | 25<br>1.0 | 2400 | 3900 | 1.5 | 1.0<br>2.3 |
| PAUL CR<br>P6 | 49 15<br>120 01 | 106 | .67 | .40 | 120 | 400<br>.47 | 5.0 | 25<br>1.0 | 570 | 1800 | 4.3 | 2.3<br>8.2 |

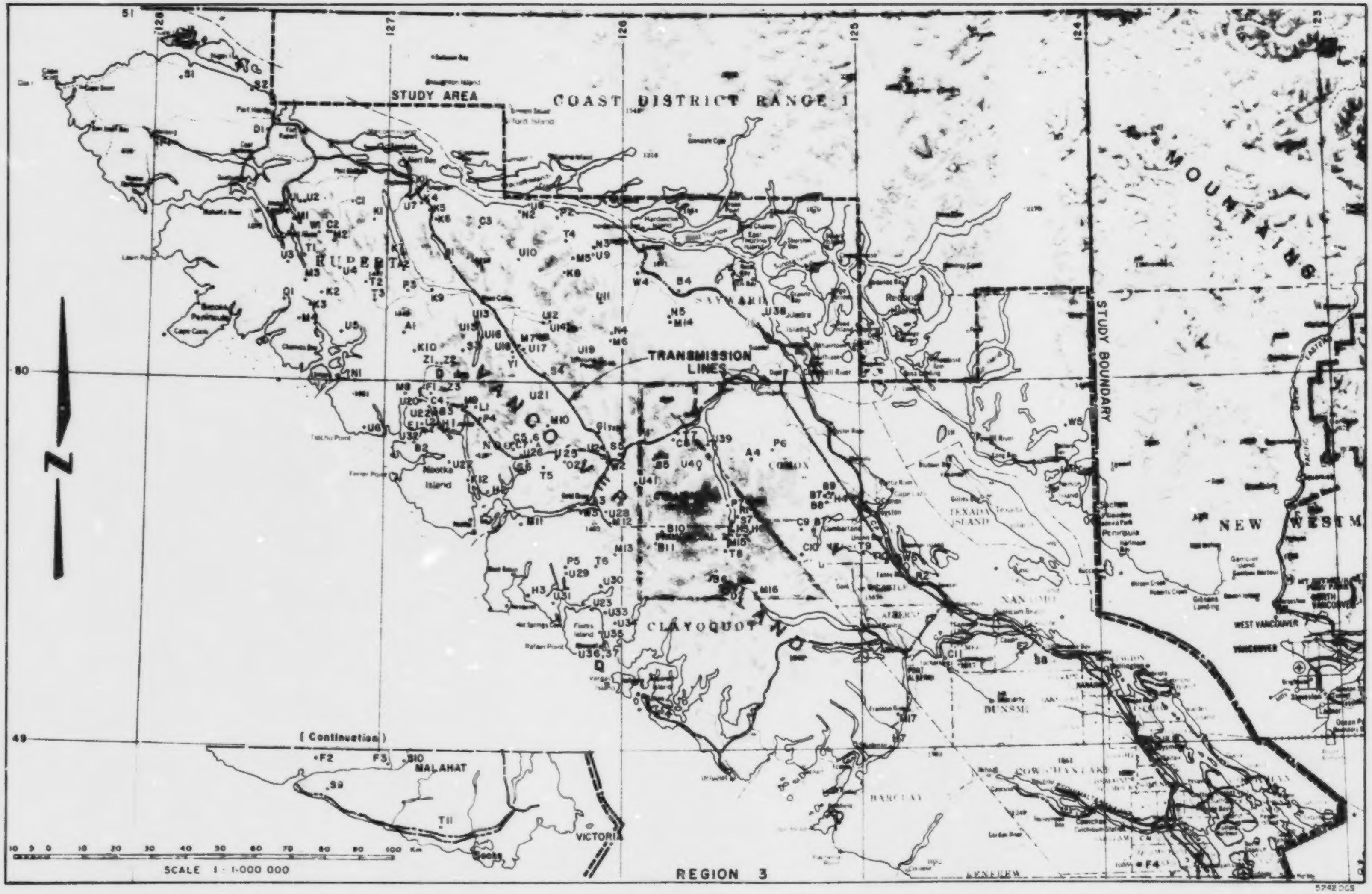
| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAVILION CR<br>P3 | 50 54<br>121 46 | 38 | .15 | .50 | 350 | 2350<br>.36 | 3.0 | 60<br>0.0 | 400 | 2200 | 6.2 | 3.4<br>11 |
| PERKETTS CR<br>P2 | 49 53<br>123 52 | 27 | 1.9 | .55 | 340 | 1000<br>.68 | 1.0 | 25<br>15 | 4500 | 4200 | 1.0 | 0.5<br>1.8 |
| PLACER CR<br>P5 | 49 11<br>120 34 | 69 | .69 | .45 | 250 | 1900<br>.55 | 2.0 | 25<br>25 | 1200 | 3200 | 3.2 | 1.4<br>7.5 |
| POST CR<br>P4 | 49 05<br>121 28 | 22 | 1.1 | .60 | 125 | 500<br>.59 | 1.5 | 25<br>17 | 1020 | 1800 | 1.7 | 1.0<br>2.8 |
| POTLATCH CR<br>P1 | 49 35<br>123 19 | 4 | .43 | .55 | 150 | 1300<br>.47 | 2.0 | 138<br>1.0 | 470 | 2100 | 4.6 | 2.8<br>7.5 |
| RAINY R<br>R3 | 49 32<br>123 30 | 56 | 7.0 | .55 | 60 | 800<br>1.5 | 3.0 | 25<br>3.0 | 3070 | 6200 | 2.1 | 1.4<br>3.1 |
| RED CR<br>R6 | 49 31<br>120 23 | 110 | .28 | .40 | 260 | 1250<br>.41 | 5.0 | 25<br>4.0 | 540 | 2100 | 5.4 | 2.4<br>12 |
| RED TUSK CR<br>R1 | 49 47<br>123 25 | 32 | 2.6 | .55 | 180 | 1400<br>.90 | 3.0 | 138<br>13 | 3300 | 5800 | 1.8 | 1.1<br>2.9 |
| REINECKER CR<br>R7 | 50 47<br>119 13 | 48 | .96 | .45 | 100 | 500<br>.58 | 0.0 | 25<br>4.0 | 690 | 1400 | 2.6 | 1.0<br>7.0 |
| ROARING CR<br>R4 | 49 27<br>122 13 | 20 | 1.4 | .55 | 200 | 900<br>.65 | 1.0 | 25<br>25 | 2000 | 2700 | 1.4 | 0.5<br>3.7 |
| ROGERS CR<br>R5 | 49 59<br>122 27 | 148 | 10 | .57 | 120 | 1200<br>1.6 | 5.0 | 138<br>1.0 | 9100 | 11300 | 1.2 | 0.8<br>1.8 |
| RUBBLE CR<br>R2 | 49 57<br>123 07 | 56 | 2.8 | .60 | 730 | 3000<br>.83 | 5.0 | 25<br>4.0 | 14700 | 19600 | 1.3 | 0.5<br>3.3 |
| SCUZZZY CR<br>S7 | 49 49<br>121 28 | 226 | 7.9 | .47 | 70 | 1100<br>1.6 | 2.0 | 25<br>3.0 | 3900 | 8500 | 2.6 | 0.8<br>8.1 |
| SECHELT CR<br>S3 | 49 40<br>123 33 | 75 | 6.0 | .55 | 153 | 1200<br>1.3 | 2.0 | 138<br>0.5 | 6600 | 7200 | 1.1 | 0.7<br>1.7 |
| SHAKAN CR<br>S6 | 50 16<br>121 12 | 86 | .86 | .43 | 50 | 200<br>.53 | 2.0 | 25<br>2.0 | 300 | 1300 | 4.6 | 1.7<br>12 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SHULAPS CR<br>S5 | 50 56<br>122 17 | 58 | .58 | .52 | 200 | 1550<br>.52 | 5.0 | 60<br>30 | 830 | 3200 | 4.2 | 2.2<br>7.8 |
| SIGURD CR FALLS<br>S4 | 49 54<br>123 20 | 22 | 1.7 | .55 | N/A | N/A<br>N/A | 3.0 | 230<br>6.0 | N/A | N/A | N/A | N/A<br>N/A |
| SIWASH CR<br>S10 | 49 34<br>121 24 | 66 | 3.0 | .50 | 200 | 600<br>.81 | 15 | 25<br>12 | 4200 | 5700 | 1.5 | 0.6<br>3.7 |
| SOWERBY CR<br>S9 | 49 19<br>121 26 | 30 | 1.4 | .63 | 425 | 3400<br>.71 | 3.0 | 25<br>7.0 | 4100 | 9800 | 2.1 | 1.2<br>3.6 |
| SPAHOMIN CR @ RAP<br>S12 | 50 03<br>120 06 | N/A | .67 | .50 | N/A | N/A<br>N/A | 6.0 | 25<br>14 | N/A | N/A | N/A | N/A<br>N/A |
| SPUZZUM CR<br>S8 | 49 39<br>121 26 | 213 | 7.5 | .60 | 50 | 500<br>1.4 | 2.0 | 25<br>2.0 | 2600 | 5100 | 1.8 | 0.3<br>9.7 |
| SQUAMISH R<br>S1 | 50 10<br>123 24 | 290 | 26 | .60 | 60 | 1400<br>2.6 | 2.0 | 230<br>30 | 11400 | 22400 | 1.9 | 1.1<br>3.1 |
| STAWAMUS CR<br>S2 | 49 42<br>123 07 | 33 | 2.8 | .55 | 274 | 2650<br>.97 | 0.0 | 25<br>3.0 | 5500 | 9400 | 1.8 | 1.1<br>2.7 |
| SWANEE CR<br>S11 | 49 15<br>121 23 | 5 | .23 | .60 | 460 | 1900<br>.36 | 2.0 | 25<br>17 | 770 | 2100 | 2.5 | 1.5<br>4.3 |
| TANTALUS CR<br>T1 | 49 51<br>123 15 | 12 | .90 | .55 | 762 | 3000<br>.45 | 5.0 | 230<br>2.0 | 4900 | 9200 | 1.9 | 1.2<br>3.2 |
| TAQUAT CR<br>T2 | 49 45<br>123 25 | 38 | 3.1 | .55 | 305 | 1400<br>.88 | 2.0 | 138<br>11 | 6700 | 7100 | 1.1 | 0.7<br>1.7 |
| TEXAS CR<br>T13 | 50 34<br>121 49 | 170 | 2.6 | .50 | 150 | 900<br>.86 | 0.5 | 25<br>18 | 2700 | 3600 | 1.5 | 0.6<br>3.8 |
| TEXAS CR<br>T12 | 50 31<br>121 50 | 153 | 2.3 | .50 | 100 | 800<br>.87 | 5.0 | 25<br>23 | 1600 | 3800 | 2.6 | 1.0<br>6.6 |
| THOMAS LAKE<br>T10 | 49 36<br>122 25 | 14 | 1.1 | .60 | 520 | 1700<br>.57 | 0.5 | 69<br>50 | 4100 | 5500 | 1.2 | 0.6<br>2.6 |
| THORNHILL CR<br>T4 | 49 40<br>123 36 | 15 | 1.2 | .55 | 459 | 1250<br>.57 | 2.0 | 138<br>0.0 | 3970 | 4220 | 1.1 | 0.7<br>1.8 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIPELLA CR<br>T11 | 49 45<br>122 10 | 61 | 4.9 | .55 | 90 | 300<br>.99 | 1.5 | 360<br>0.0 | 3200 | 3600 | 1.2 | 0.6<br>2.4 |
| TOMMY CR<br>T5 | 50 50<br>122 31 | 68 | 1.2 | .52 | 300 | 1800<br>.64 | 0.0 | 60<br>20 | 2500 | 4140 | 1.8 | 0.8<br>4.4 |
| TRETHEWAY CR<br>T9 | 49 42<br>122 05 | 94 | 7.5 | .55 | 30 | 150<br>1.3 | 0.5 | 360<br>0.0 | 1600 | 3500 | 2.2 | 1.1<br>4.6 |
| TRUAX CR<br>T8 | 50 53<br>122 38 | 50 | 1.0 | .52 | 200 | 700<br>.55 | 0.0 | 60<br>18 | 1400 | 2040 | 1.6 | 0.7<br>3.3 |
| TSILEUH CR<br>T14 | 49 46<br>121 26 | 29 | .87 | .47 | 700 | 3900<br>.57 | 0.0 | 25<br>5.0 | 4300 | 11500 | 3.2 | 0.8<br>13 |
| TWENTYONE MILE CR<br>T7 | 50 07<br>122 59 | 28 | 2.2 | .60 | 185 | 1000<br>.80 | 3.0 | 25<br>1.5 | 2900 | 3600 | 1.2 | 0.7<br>2.0 |
| TWIN ONE CR<br>T6 | 50 15<br>122 30 | 57 | 2.3 | .56 | 430 | 4100<br>.90 | 5.0 | 138<br>1.0 | 6900 | 19500 | 2.8 | 1.6<br>4.9 |
| TZOONIE CR<br>T3 | 49 47<br>123 43 | 159 | 11 | .55 | 30 | 320<br>1.7 | 0.5 | 25<br>23 | 2400 | 5230 | 2.3 | 1.2<br>4.1 |
| UNNAMED CR<br>U4 | 49 45<br>123 31 | 69 | 5.5 | .55 | 122 | 350<br>1.0 | 0.0 | 138<br>6.0 | 4800 | 3770 | 0.8 | 0.5<br>1.3 |
| UNNAMED CR<br>U5 | 49 44<br>123 32 | 5.5 | .44 | .55 | 397 | 700<br>.41 | 1.0 | 138<br>5.0 | 1300 | 1730 | 1.4 | 0.8<br>2.2 |
| UNNAMED CR<br>U3 | 49 55<br>123 46 | 13 | .88 | .55 | 579 | 3000<br>.56 | 0.0 | 25<br>25 | 3650 | 8070 | 2.3 | 1.3<br>4.2 |
| UNNAMED CR<br>U23 | 49 12<br>121 20 | 5.8 | .26 | .63 | 670 | 2050<br>.36 | 4.0 | 25<br>24 | 1300 | 3400 | 2.4 | 1.4<br>4.0 |
| UNNAMED CR<br>U18 | 49 15<br>121 15 | 21 | .93 | .60 | 180 | 1300<br>.61 | 2.0 | 25<br>25 | 1200 | 2900 | 2.2 | 1.3<br>3.9 |
| UNNAMED CR<br>U26 | 49 18<br>120 04 | 13 | .08 | .40 | 600 | 1300<br>.20 | 2.0 | 25<br>1.0 | 340 | 1100 | 4.5 | 2.4<br>8.7 |
| UNNAMED CR<br>U10 | 49 41<br>123 16 | 4.1 | .41 | .55 | 580 | 1700<br>.41 | 4.0 | 25<br>2.5 | 1770 | 3400 | 2.0 | 1.2<br>3.2 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNNAMED CR<br>U15 | 49 47<br>123 34 | 19 | 1.4 | .55 | 457 | 1200<br>.60 | 10 | 138<br>17 | 4600 | 5900 | 1.3 | 0.8<br>2.2 |
| UNNAMED CR<br>U17 | 49 09<br>121 15 | 20 | .90 | .63 | 245 | 1500<br>.59 | 3.0 | 25<br>30 | 1570 | 3500 | 2.0 | 1.2<br>3.4 |
| UNNAMED CR<br>U2 | 49 49<br>123 23 | 4.7 | .38 | .55 | 793 | 1150<br>.36 | 2.0 | 138<br>17 | 2200 | 3300 | 1.6 | 1.0<br>2.5 |
| UNNAMED CR<br>U14 | 49 43<br>123 45 | 13 | 1.0 | .55 | 427 | 1200<br>.54 | 2.0 | 25<br>17 | 3200 | 3800 | 1.2 | 0.8<br>2.0 |
| UNNAMED CR<br>U11 | 49 48<br>123 24 | 9.4 | 0.8 | .55 | 793 | 2700<br>.49 | 6.0 | 138<br>15 | 4280 | 9100 | 2.2 | 1.4<br>3.6 |
| UNNAMED CR<br>U20 | 49 40<br>121 51 | 13 | .65 | .60 | 540 | 2000<br>.47 | 4.0 | 25<br>55 | 2500 | 4800 | 1.8 | 0.8<br>4.0 |
| UNNAMED CR<br>U22 | 49 57<br>121 50 | 58 | 2.3 | .47 | 250 | 1500<br>.83 | 5.0 | 25<br>28 | 5800 | 9600 | 1.8 | 0.7<br>4.7 |
| UNNAMED CR<br>U25 | 49 05<br>120 43 | 9 | .18 | .50 | 150 | 825<br>.36 | 2.0 | 25<br>11 | 200 | 1250 | 6.9 | 3.4<br>13 |
| UNNAMED CR<br>U24 | 49 09<br>121 20 | 26 | 1.2 | .63 | 243 | 2100<br>.69 | 5.0 | 25<br>30 | 2000 | 5000 | 2.2 | 1.3<br>3.7 |
| UNNAMED CR<br>U6 | 49 46<br>123 26 | 7.8 | .62 | .55 | 458 | 1100<br>.45 | 2.0 | 138<br>14 | 2090 | 2700 | 1.3 | 0.8<br>2.1 |
| UNNAMED CR<br>U7 | 49 45<br>123 27 | 11 | .88 | .55 | 550 | 1100<br>.48 | 2.0 | 138<br>11 | 3500 | 3700 | 1.1 | 0.7<br>1.8 |
| UNNAMED CR<br>U21 | 49 50<br>121 31 | 58 | 2.0 | .47 | 300 | 2200<br>.82 | 3.0 | 25<br>9.0 | 4300 | 7700 | 2.1 | 0.7<br>6.7 |
| UNNAMED CR<br>U12 | 49 45<br>123 43 | 19 | 1.5 | .55 | 214 | 600<br>.62 | 1.0 | 25<br>18 | 2340 | 2500 | 1.1 | 0.7<br>1.8 |
| UNNAMED CR<br>U1 | 50 01<br>123 21 | 22 | 1.8 | .60 | 275 | 700<br>.64 | 8.0 | 230<br>15 | 3500 | 3900 | 1.1 | 0.6<br>1.8 |
| UNNAMED CR<br>U19 | 49 29<br>121 25 | 11 | .45 | .60 | 425 | 2600<br>.45 | 5.0 | 25<br>3.0 | 1300 | 3800 | 2.6 | 1.5<br>4.7 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNNAMED CR<br>U13 | 49 41<br>123 35 | 2.3 | .18 | .57 | 793 | 1800<br>.31 | 3.0 | 138<br>0.0 | 1100 | 2860 | 2.6 | 1.6<br>4.2 |
| UNNAMED CR FALLS<br>U9 | 49 50<br>123 14 | 14 | 1.1 | .55 | N/A | N/A<br>N/A | 4.0 | 25<br>8.0 | N/A | N/A | N/A | N/A<br>N/A |
| UNNAMED CR<br>U8 | 49 40<br>123 35 | 1.9 | .15 | .60 | 1037 | 2400<br>.25 | 3.0 | 138<br>0.0 | 1140 | 3300 | 2.8 | 1.7<br>4.6 |
| URE CR<br>U16 | 50 16<br>122 35 | 119 | 6.0 | .57 | 275 | 2050<br>1.2 | 15 | 25<br>10 | 11800 | 16500 | 1.4 | 0.8<br>2.6 |
| VANCOUVER R<br>V1 | 49 56<br>123 48 | 115 | 8.1 | .55 | 60 | 900<br>1.6 | 2.5 | 25<br>25 | 3500 | 7800 | 2.3 | 1.2<br>4.1 |
| WEDGE CR<br>W2 | 50 10<br>122 54 | 51 | 3.6 | .60 | 215 | 1500<br>1.0 | 3.0 | 25<br>2.0 | 5500 | 6500 | 1.1 | 0.6<br>2.0 |
| WHITE CR<br>W5 | 50 51<br>119 19 | 60 | .60 | .60 | 50 | 300<br>.50 | 0.0 | 25<br>0.0 | 210 | 900 | 3.9 | 1.5<br>10 |
| WHITECAP CR<br>W1 | 50 43<br>122 18 | 73 | .73 | .52 | 200 | 950<br>.52 | 2.0 | 60<br>1.0 | 1050 | 2220 | 2.3 | 1.3<br>4.3 |
| WILLIS CR<br>W4 | 49 25<br>120 25 | 120 | .60 | .45 | 150 | 1200<br>.53 | 4.0 | 25<br>9.0 | 640 | 2400 | 4.6 | 2.7<br>7.9 |
| WRAY CR<br>W3 | 49 20<br>121 18 | 18 | .83 | .60 | 305 | 2000<br>.57 | 3.0 | 25<br>12 | 1800 | 3600 | 1.9 | 1.1<br>3.2 |
| ZENITH CR<br>Z1 | 49 52<br>123 16 | 1.5 | .11 | .60 | 1159 | 2800<br>.25 | 5.0 | 25<br>15 | 980 | 3800 | 3.7 | 2.2<br>6.2 |



REGION 3

STUDY AREA
COAST DISTRICT RANGE 1
MOUNTAINS
STUDY BOUNDARY
TRANSMISSION LINES
NEW WESTM
RUPERT
SAYWARD
COMOX
CLAYOQUOT
NANAIMO
TEXADA ISLAND
DUNSMUIR
COWICHAN LAKE
BARCLAY
RENFREW
ALBERNI
MALAHAT
VICTORIA
WEST VANCOUVER
NORTH VANCOUVER
VANCOUVER
Nootka Island
( Continuation )
SCALE 1 : 1 000 000
10 0 10 20 30 40 50 60 70 80 90 100 Km
N
51
50
49
128
127
126
125
124
123
5242 DCS

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADRIAN CR<br>A4 | 49 48<br>125 27 | 26 | 1.8 | .65 | 50 | 625<br>.87 | 0.0 | 25<br>0.0 | 650 | 2500 | 3.3 | 1.8<br>6.0 |
| AHAMINGUS CR<br>A3 | 49 41<br>126 07 | 10 | .99 | .65 | 40 | 100<br>.52 | 0.8 | 25<br>0.5 | 280 | 1200 | 3.5 | 2.1<br>5.7 |
| ARTLISH R<br>A1 | 50 08<br>126 55 | 49 | 5.9 | .65 | 30 | 600<br>1.5 | 6.0 | 138<br>30 | 1300 | 6000 | 4.0 | 2.6<br>6.3 |
| ATLUCK CR<br>A2 | 50 18<br>126 56 | 72 | 8.6 | .65 | 30 | 700<br>1.7 | 1.0 | 138<br>16 | 1900 | 7000 | 3.2 | 2.1<br>5.1 |
| BANCROFT CR<br>B11 | 49 34<br>125 52 | 29 | 2.2 | .65 | 100 | 560<br>0.8 | 15 | 138<br>26 | 1500 | 4700 | 2.6 | 1.5<br>4.6 |
| BARR CR<br>B3 | 49 55<br>126 47 | 25 | 3.5 | .65 | 30 | 400<br>1.1 | 6.0 | 25<br>10 | 760 | 3800 | 4.3 | 2.8<br>6.7 |
| BEDWELL R<br>B6 | 49 27<br>125 36 | 25 | 3.1 | .62 | 50 | 500<br>1.0 | 0.0 | 138<br>32 | 1100 | 3000 | 2.5 | 1.6<br>3.9 |
| BEECH CR<br>B7 | 49 36<br>125 12 | 19 | 1.3 | .65 | 50 | 125<br>.57 | 0.0 | 25<br>8.2 | 460 | 1100 | 1.9 | 1.2<br>3.0 |
| BIG TREE CR<br>B4 | 50 15<br>125 45 | 35 | 1.7 | .67 | 100 | 1900<br>.92 | 1.5 | 25<br>1.5 | 1250 | 6000 | 4.1 | 2.3<br>7.4 |
| BONANZA R<br>B1 | 50 20<br>126 44 | 68 | 4.4 | .68 | 60 | 1400<br>1.4 | 1.0 | 138<br>0.8 | 1900 | 7800 | 3.4 | 2.2<br>5.3 |
| BRODRICK CR<br>B2 | 49 50<br>126 53 | 9 | 1.4 | .65 | 120 | 1650<br>.79 | 3.0 | 25<br>21 | 1100 | 4500 | 3.3 | 2.2<br>5.2 |
| BROWNS R #1<br>B8 | 49 41<br>125 09 | 75 | 5.9 | .65 | 50 | 400<br>1.2 | 0.3 | 25<br>2.1 | 2100 | 3400 | 1.4 | 1.0<br>2.1 |
| BROWNS R #2<br>B9 | 49 42<br>125 08 | 82 | 6.4 | .65 | 50 | 750<br>1.4 | 1.2 | 25<br>2.0 | 2300 | 5100 | 1.9 | 1.3<br>2.8 |
| BURMAN R<br>B10 | 49 36<br>125 50 | 55 | 4.4 | .65 | 50 | 250<br>1.0 | 13 | 138<br>26 | 1600 | 4400 | 2.4 | 1.4<br>4.2 |
| BUTTERWORT/ELK CR<br>B5 | 49 48<br>125 53 | 33 | 2.6 | .65 | 50 | 375<br>.91 | 6.5 | 138<br>6.3 | 950 | 3200 | 2.9 | 1.7<br>5.0 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAMERON R<br>C11 | 49 15<br>124 40 | 78 | 6.2 | .55 | 50 | 250<br>1.2 | 0.3 | 25<br>9.0 | 2200 | 3000 | 1.4 | 0.7<br>2.7 |
| CANTON CR<br>C7 | 49 49<br>126 28 | 31 | 3.1 | .65 | 30 | 800<br>1.2 | 1.4 | 138<br>1.5 | 680 | 4500 | 5.7 | 3.5<br>9.3 |
| CANTON CR EAST<br>C5 | 49 50<br>126 28 | 11 | 1.1 | .65 | 30 | 150<br>.61 | 3.4 | 138<br>4.4 | 240 | 1500 | 5.2 | 3.2<br>8.4 |
| CANTON CR WEST<br>C6 | 49 50<br>126 28 | 20 | 2.0 | .65 | 30 | 300<br>.86 | 4.0 | 138<br>4.0 | 440 | 2400 | 4.6 | 2.8<br>7.5 |
| CATHERINE CR<br>C3 | 50 25<br>126 36 | 47 | 3.0 | .68 | 90 | 1100<br>1.0 | 11 | 138<br>19 | 1970 | 6500 | 2.8 | 1.5<br>5.1 |
| CERVUS CR @ LADY F<br>C8 | 49 51<br>125 47 | 55 | 5.5 | .65 | 100 | 380<br>1.1 | 0.9 | 138<br>1.6 | 3900 | 3800 | 0.8 | 0.5<br>1.2 |
| CIRIACO CR<br>C4 | 49 56<br>126 49 | 3.5 | .49 | .65 | 90 | 550<br>.46 | 6.0 | 25<br>8.0 | 320 | 2000 | 5.2 | 3.4<br>8.1 |
| CLUXEWE R<br>C1 | 50 29<br>127 09 | 23 | 1.8 | .65 | 60 | 550<br>.82 | 2.5 | 25<br>11 | 800 | 2600 | 2.8 | 1.6<br>4.9 |
| COMOX CR<br>C10 | 49 32<br>125 15 | 28 | 2.0 | .65 | 50 | 125<br>.67 | 0.8 | 25<br>18 | 720 | 1500 | 1.7 | 1.1<br>2.7 |
| CRAFT CR<br>C2 | 50 24<br>127 15 | 15 | 1.2 | .65 | 180 | 1800<br>.71 | 3.0 | 25<br>18 | 1500 | 4000 | 2.2 | 1.3<br>3.8 |
| CRUICKSHANK R<br>C9 | 49 36<br>125 15 | 77 | 5.4 | .65 | 150 | 2000<br>1.3 | 0.1 | 25<br>18 | 5800 | 8900 | 1.3 | 0.9<br>2.1 |
| DICK BOOTH CR<br>D1 | 50 41<br>127 31 | 18 | 1.3 | .68 | 90 | 1500<br>.82 | 2.5 | 25<br>2.5 | 880 | 5000 | 4.7 | 2.6<br>8.5 |
| DRINKWATER CR<br>D2 | 49 26<br>125 30 | 26 | 3.3 | .62 | 50 | 250<br>.92 | 8.0 | 138<br>23 | 1100 | 3300 | 2.6 | 1.6<br>4.0 |
| EHATISAHT CR<br>E1 | 49 53<br>126 51 | 11 | 1.5 | .65 | 60 | 800<br>.82 | 13 | 25<br>17 | 670 | 4600 | 6.0 | 3.9<br>9.2 |
| ENGLISHMAN R<br>E2 | 49 15<br>124 21 | 149 | 10 | .55 | 50 | 1630<br>2.0 | 1.0 | 25<br>2.3 | 3700 | 11300 | 3.1 | 1.7<br>5.7 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FAIRY CR<br>F2 | 48 36<br>124 20 | 7 | .55 | .51 | 50 | 125<br>.44 | 0.5 | 25<br>5.5 | 200 | 820 | 4.5 | 2.7<br>7.4 |
| FELLOWS CR<br>F4 | 48 40<br>123 53 | 9 | .45 | .51 | 50 | 250<br>.44 | 0.5 | 25<br>15 | 160 | 710 | 4.8 | 2.2<br>11 |
| FLEET R<br>F3 | 48 35<br>124 03 | 64 | 5.0 | .51 | 50 | 750<br>1.3 | 1.0 | 25<br>24 | 1800 | 5000 | 3.1 | 1.9<br>5.0 |
| FRIEND CR<br>F1 | 49 58<br>126 48 | 2.5 | .38 | .65 | 90 | 300<br>.41 | 0.6 | 25<br>3.0 | 260 | 960 | 3.2 | 2.2<br>4.9 |
| GOLD R<br>G1 | 49 52<br>126 06 | 198 | 20 | .65 | 30 | 900<br>2.5 | 0.6 | 138<br>4.4 | 4400 | 13000 | 2.6 | 1.7<br>3.9 |
| HANDY CR<br>H7 | 49 00<br>124 56 | 32 | 3.8 | .62 | 100 | 310<br>.89 | 1.0 | 25<br>29 | 2700 | 2900 | 1.0 | 0.6<br>1.7 |
| HEADQUARTERS CR<br>H4 | 49 42<br>125 07 | 24 | 1.5 | .65 | 50 | 250<br>.68 | 0.8 | 25<br>1.4 | 540 | 1400 | 2.3 | 1.4<br>3.5 |
| HECTATE LAKE<br>H1 | 49 53<br>126 47 | 8.0 | 1.1 | .65 | 30 | 500<br>.76 | 0.6 | 25<br>16 | 240 | 1900 | 6.9 | 4.4<br>11 |
| HENSHAW CR #1<br>H5 | 49 36<br>125 32 | 33 | 2.5 | .65 | 50 | 500<br>.94 | 1.6 | 138<br>43 | 890 | 2900 | 2.8 | 1.6<br>4.9 |
| HENSHAW CR #2<br>H6 | 49 36<br>125 32 | 34 | 2.6 | .65 | 50 | 500<br>.95 | 0.5 | 138<br>43 | 910 | 2800 | 2.6 | 1.5<br>4.6 |
| HESQUIAT PT CR<br>H3 | 49 25<br>126 23 | 15 | 1.5 | .65 | 40 | 700<br>.87 | 1.5 | 25<br>38 | 440 | 3100 | 6.1 | 3.8<br>10 |
| HOISS CR<br>H2 | 49 42<br>126 34 | 12 | 1.3 | .65 | 60 | 950<br>0.8 | 2.0 | 138<br>17 | 570 | 3000 | 4.7 | 3.1<br>7.0 |
| KAIPIT CR<br>K9 | 50 15<br>126 48 | 81 | 9.7 | .65 | 60 | 700<br>1.6 | 0.3 | 138<br>6.0 | 4200 | 7000 | 1.4 | 0.9<br>2.3 |
| KAOUK R<br>K10 | 50 05<br>126 52 | 30 | 3.6 | .65 | 60 | 1400<br>1.3 | 1.4 | 25<br>18 | 1600 | 7300 | 4.1 | 2.6<br>6.4 |
| KASHULT R<br>K3 | 50 12<br>127 19 | 19 | 1.5 | .64 | 60 | 950<br>.83 | 2.0 | 25<br>32 | 630 | 3700 | 5.1 | 3.1<br>8.3 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KAUWINCH R<br>K2 | 50 14<br>127 16 | 16 | 1.2 | .64 | 120 | 900<br>.68 | 7.0 | 25<br>24 | 1000 | 3310 | 2.8 | 1.7<br>4.5 |
| KENDRICK CR<br>K12 | 49 44<br>126 39 | 16 | 1.6 | .65 | 30 | 620<br>.91 | 1.0 | 138<br>23 | 350 | 2900 | 7.2 | 4.8<br>11 |
| KILPALA R<br>K1 | 50 26<br>127 03 | 52 | 4.1 | .65 | 60 | 1700<br>1.4 | 13 | 25<br>17 | 1800 | 9700 | 4.7 | 2.7<br>8.0 |
| KINMAN CR<br>K7 | 50 21<br>126 55 | 23 | 1.5 | .68 | 90 | 1050<br>0.8 | 1.4 | 138<br>21 | 980 | 3200 | 2.7 | 1.5<br>5.0 |
| KOKISH R<br>K5 | 50 28<br>126 48 | 84 | 5.5 | .68 | 60 | 1400<br>1.5 | 1.7 | 138<br>2.8 | 2390 | 8500 | 3.0 | 2.1<br>4.3 |
| KOKISH R<br>K4 | 50 29<br>126 50 | 265 | 17 | .68 | 30 | 950<br>2.4 | 0.0 | 138<br>0.7 | 3700 | 15000 | 3.3 | 2.3<br>4.9 |
| KOKISH R<br>K11 | 50 31<br>126 52 | 282 | 18 | .68 | 90 | 1150<br>2.1 | 2.5 | 138<br>0.5 | 12000 | 17000 | 1.2 | 0.8<br>1.7 |
| KOKISH R<br>K6 | 50 27<br>126 47 | 80 | 5.2 | .68 | 127 | 1900<br>1.3 | 2.0 | 138<br>3.0 | 4700 | 9900 | 1.7 | 1.2<br>2.5 |
| KUNNUM CR<br>K8 | 50 18<br>126 14 | 48 | 2.9 | .64 | 91 | 2050<br>1.2 | 2.5 | 25<br>27 | 1900 | 9000 | 4.2 | 2.2<br>8.1 |
| LEINER R<br>L1 | 49 56<br>126 37 | 58 | 8.1 | .65 | 30 | 350<br>1.5 | 2.0 | 25<br>4.0 | 1700 | 4800 | 2.4 | 1.5<br>3.7 |
| LUTES CR<br>L2 | 49 53<br>126 46 | 11 | 1.5 | .65 | 60 | 450<br>.74 | 7.5 | 25<br>14 | 670 | 2800 | 3.6 | 2.3<br>5.5 |
| MACKTUSH CR<br>M17 | 49 06<br>124 51 | 24 | 2.9 | .62 | 50 | 625<br>1.0 | 0.2 | 25<br>10 | 1000 | 3000 | 2.6 | 1.5<br>4.5 |
| MALKSOPE R<br>M4 | 50 10<br>127 22 | 15 | 1.1 | .64 | 60 | 1050<br>.77 | 1.8 | 25<br>26 | 490 | 3100 | 5.5 | 3.4<br>9.0 |
| MAMAT CR<br>M8 | 49 59<br>126 55 | 4.5 | .63 | .65 | 60 | 600<br>.56 | 1.3 | 25<br>6.0 | 270 | 1700 | 5.3 | 3.4<br>8.1 |
| MAQUILLA CR<br>M7 | 50 05<br>126 25 | 45 | 3.4 | .64 | 90 | 1650<br>1.2 | 1.3 | 138<br>0.8 | 2200 | 7700 | 3.1 | 1.9<br>5.0 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MARBLE R<br>M3 | 50 16<br>127 20 | 12 | .93 | .65 | 60 | 900<br>.70 | 8 | 25<br>17 | 400 | 3000 | 6.4 | 3.9<br>11 |
| MARBLE R CANYON<br>M1 | 50 26<br>127 23 | 128 | 11 | .70 | 33 | 1700<br>2.2 | 0.5 | 25<br>5.0 | 2580 | 16000 | 5.2 | 3.5<br>7.5 |
| MARGARET CR<br>M16 | 49 26<br>125 27 | 23 | 2.9 | .62 | 50 | 250<br>.87 | 8.0 | 138<br>23 | 1000 | 3200 | 2.8 | 1.8<br>4.3 |
| MATCHLEE CR<br>M12 | 49 39<br>126 03 | 14 | 1.4 | .65 | 40 | 100<br>.59 | 10 | 25<br>11 | 400 | 2400 | 5.1 | 3.1<br>8.3 |
| MAYNARD L<br>M2 | 50 24<br>127 14 | 114 | 9.1 | .65 | 64 | 550<br>1.5 | 0.0 | 25<br>18 | 4190 | 5400 | 1.1 | 0.6<br>1.9 |
| McKELVIE CR<br>M9 | 49 56<br>126 39 | 20 | 2.4 | .65 | 90 | 600<br>.86 | 0.5 | 25<br>4.0 | 1580 | 3100 | 1.7 | 1.1<br>2.7 |
| MEGIN R TRIBUTARY<br>M13 | 49 32<br>126 01 | 13 | 1.3 | .65 | 40 | 275<br>.69 | 10 | 25<br>47 | 380 | 2600 | 6.0 | 3.7<br>9.8 |
| MEMEKAY R<br>M14 | 50 10<br>125 47 | 103 | 4.1 | .67 | 50 | 1000<br>1.3 | 0.3 | 25<br>7.5 | 1400 | 5400 | 3.1 | 1.5<br>6.2 |
| MOAKWA CR<br>M6 | 50 07<br>126 02 | 41 | 3.1 | .64 | 90 | 1250<br>1.1 | 1.4 | 138<br>22 | 2000 | 5900 | 2.6 | 1.6<br>4.2 |
| MONTAGUE CR<br>M5 | 50 20<br>126 12 | 37 | 2.2 | .64 | 152 | 1500<br>.90 | 3.0 | 25<br>22 | 2400 | 5800 | 2.1 | 1.1<br>4.1 |
| MOOYAH R<br>M11 | 49 37<br>126 25 | 17 | 1.7 | .65 | 40 | 900<br>.95 | 0.0 | 25<br>32 | 490 | 3800 | 6.7 | 4.1<br>11 |
| MUCHALAT R<br>M10 | 49 53<br>126 19 | 20 | 2.0 | .65 | 60 | 350<br>.78 | 5.0 | 138<br>12 | 880 | 2500 | 2.4 | 1.5<br>4.0 |
| MYRA CR AT FALLS<br>M15 | 49 35<br>125 34 | 70 | 5.3 | .65 | 50 | 1200<br>1.5 | 0.9 | 138<br>40 | 1800 | 7200 | 3.3 | 1.9<br>5.9 |
| NAKA CR<br>N2 | 50 28<br>126 25 | 53 | 3.2 | .64 | 60 | 750<br>1.1 | 11 | 138<br>31 | 1400 | 5500 | 3.5 | 1.8<br>6.7 |
| NARROWGUT CR<br>N1 | 50 00<br>127 07 | 18 | 1.8 | .65 | 30 | 400<br>.87 | 6.0 | 25<br>27 | 390 | 2900 | 6.4 | 4.3<br>9.5 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NEWCASTLE CR<br>N3 | 50 22<br>126 07 | 33 | 2.0 | .64 | 90 | 850<br>.85 | 1.1 | 25<br>15 | 1300 | 3600 | 2.4 | 1.3<br>4.7 |
| NORA CR<br>N4 | 50 08<br>126 02 | 15 | 1.1 | .64 | 152 | 1200<br>.67 | 1.5 | 25<br>22 | 1200 | 3100 | 2.2 | 1.4<br>3.6 |
| NOR/MID MEMEKAY R<br>N5 | 50 11<br>125 47 | 103 | 4.1 | .67 | 50 | 1250<br>1.3 | 3.0 | 25<br>5.5 | 1400 | 6800 | 3.9 | 1.9<br>7.9 |
| OKTWANCH R<br>O2 | 49 47<br>126 15 | 16 | 1.6 | .65 | 30 | 400<br>.83 | 0.6 | 138<br>0.9 | 340 | 2100 | 5.2 | 3.2<br>8.4 |
| OUOUKINSH R<br>O1 | 50 13<br>127 25 | 12 | .92 | .64 | 120 | 1100<br>.63 | 8.0 | 25<br>21 | 800 | 3500 | 3.9 | 2.4<br>6.2 |
| PALMERSTON CR<br>P2 | 50 27<br>126 16 | 29 | 1.7 | .64 | 90 | 725<br>.79 | 1.5 | 25<br>28 | 1100 | 2800 | 2.1 | 1.1<br>4.1 |
| PEGGATTEM CR<br>P1 | 50 38<br>127 59 | 20 | 1.5 | .68 | 30 | 550<br>.87 | 0.9 | 25<br>29 | 320 | 2600 | 6.6 | 3.8<br>11.6 |
| PERRY R<br>P4 | 49 54<br>126 37 | 37 | 5.2 | .65 | 30 | 600<br>1.4 | 0.0 | 25<br>3.0 | 1140 | 4900 | 3.8 | 2.4<br>5.8 |
| PHILLIPS CR<br>P7 | 49 40<br>125 34 | 80 | 8.0 | .65 | 50 | 500<br>1.5 | 13 | 138<br>27 | 2800 | 6900 | 2.1 | 1.4<br>3.2 |
| PIGGOTT CR<br>P6 | 49 49<br>125 22 | 82 | 5.3 | .65 | 50 | 250<br>1.1 | 0.7 | 25<br>14 | 1900 | 2800 | 1.3 | 0.8<br>2.0 |
| PINDER CR<br>P3 | 50 15<br>126 55 | 25 | 3.0 | .65 | 90 | 2100<br>1.2 | 0.7 | 138<br>16 | 1900 | 9000 | 4.0 | 2.6<br>6.4 |
| PRETTY GIRL L<br>P5 | 49 30<br>126 14 | 17 | 1.7 | .65 | 80 | 400<br>.72 | 2.0 | 25<br>32 | 980 | 2200 | 1.9 | 1.2<br>3.1 |
| RALPH R<br>R1 | 49 38<br>125 31 | 23 | 1.7 | .65 | 50 | 375<br>.78 | 1.3 | 138<br>39 | 620 | 1900 | 2.6 | 1.5<br>4.6 |
| ROSEWALL CR<br>R2 | 49 27<br>124 48 | 39 | 2.9 | .62 | 100 | 630<br>.91 | 1.3 | 25<br>1.0 | 2100 | 3200 | 1.4 | 0.7<br>2.6 |
| SALMON R<br>S3 | 50 05<br>126 41 | 241 | 7.5 | .67 | 50 | 700<br>1.5 | 0.0 | 25<br>19 | 2700 | 5700 | 1.8 | 1.2<br>2.6 |

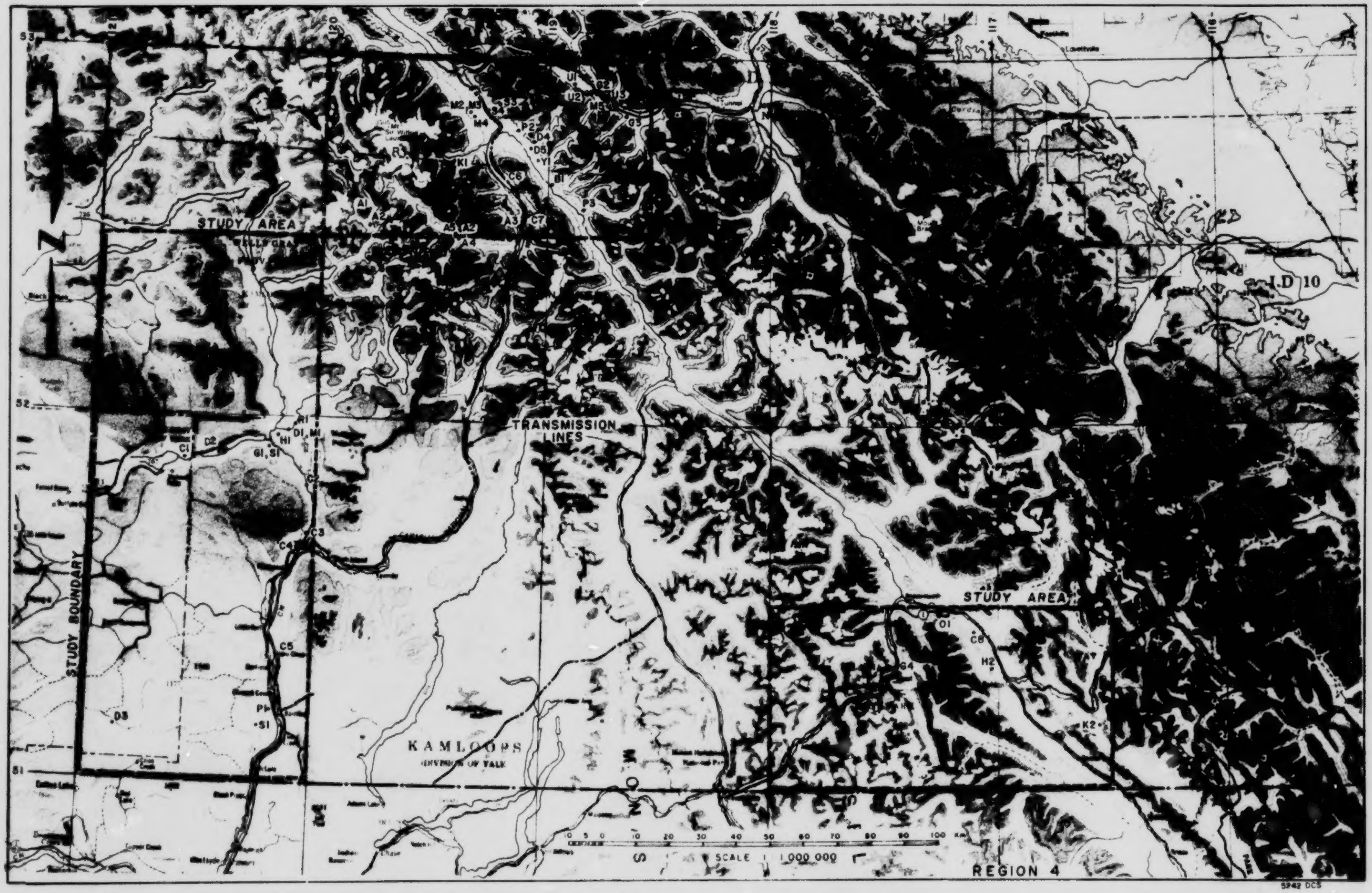
| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAN JUAN R<br>S10 | 48 36<br>123 59 | 45 | 2.3 | .51 | 50 | 750<br>.97 | 1.5 | 25<br>18 | 810 | 2800 | 3.8 | 1.8<br>8.2 |
| SAUNDERS CR<br>S5 | 49 48<br>126 01 | 31 | 3.1 | .65 | 90 | 1200<br>1.1 | 0.1 | 138<br>2.0 | 2000 | 5300 | 2.2 | 1.4<br>3.6 |
| SEBALHALL CR<br>S6 | 49 47<br>126 24 | 25 | 2.5 | .65 | 30 | 400<br>.99 | 3.0 | 138<br>10 | 560 | 2800 | 4.4 | 2.7<br>7.1 |
| SHEPHERD CR<br>S7 | 49 38<br>125 31 | 43 | 3.2 | .65 | 50 | 500<br>1.0 | 0.7 | 138<br>39 | 1200 | 3200 | 2.4 | 1.4<br>4.2 |
| SHUSHARTIE R<br>S1 | 50 49<br>127 52 | 65 | 4.9 | .68 | 30 | 750<br>1.4 | 3.0 | 25<br>28 | 1000 | 5900 | 4.6 | 2.6<br>8.1 |
| SOMBRIO R<br>S9 | 48 31<br>124 17 | 11 | .87 | .51 | 50 | 380<br>.60 | 0.0 | 25<br>0.5 | 310 | 1300 | 4.5 | 2.8<br>7.4 |
| SONGHEES CR<br>S2 | 50 47<br>127 35 | 60 | 4.5 | .68 | 30 | 450<br>1.3 | 3.0 | 25<br>8.0 | 990 | 4200 | 3.6 | 2.0<br>6.3 |
| SOUTH ENGLISHMAN R<br>S8 | 49 15<br>124 17 | 66 | 4.6 | .55 | 100 | 2000<br>1.3 | 0.1 | 25<br>5.0 | 3300 | 8400 | 2.6 | 1.4<br>4.8 |
| SWAH CR<br>S4 | 50 01<br>126 20 | 14 | 1.4 | .65 | 60 | 700<br>.78 | 0.0 | 138<br>1.9 | 620 | 2300 | 3.1 | 1.9<br>5.0 |
| TABOLT CR TRIB<br>T6 | 49 30<br>126 06 | 15 | 1.5 | .65 | 40 | 250<br>.71 | 2.0 | 25<br>28 | 430 | 1800 | 3.5 | 2.2<br>5.7 |
| TAHSISH R<br>T3 | 50 13<br>127 03 | 40 | 3.0 | .64 | 60 | 500<br>.97 | 0.8 | 138<br>45 | 1300 | 3200 | 2.2 | 1.3<br>3.5 |
| TAHSISH R<br>T2 | 50 16<br>127 05 | 47 | 3.7 | .65 | 30 | 500<br>1.2 | 0.5 | 138<br>45 | 810 | 3300 | 3.5 | 2.1<br>6.1 |
| TEIHSUM R<br>T1 | 50 20<br>127 21 | 29 | 2.3 | .65 | 60 | 1700<br>1.1 | 2.0 | 25<br>17 | 1000 | 6500 | 5.6 | 3.2<br>9.8 |
| THELWOOD CR<br>T8 | 49 33<br>125 34 | 39 | 2.9 | .65 | 100 | 1000<br>1.0 | 0.3 | 138<br>41 | 2100 | 4500 | 1.9 | 1.1<br>3.3 |
| TLATLOS CR<br>T4 | 50 23<br>126 14 | 35 | 2.1 | .64 | 182 | 2275<br>.92 | 3.0 | 25<br>26 | 2700 | 8000 | 2.6 | 1.3<br>4.9 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TLOOLS CR<br>T7 | 49 52<br>125 45 | 40 | 3.0 | .65 | 50 | 625<br>1.1 | 1.0 | 138<br>1.0 | 1070 | 3500 | 2.8 | 1.6<br>5.0 |
| TLUPANA R<br>T5 | 49 46<br>126 20 | 29 | 2.9 | .65 | 90 | 1850<br>1.1 | 2.0 | 138<br>2.0 | 1900 | 7700 | 3.6 | 2.2<br>5.8 |
| TRENT R<br>T9 | 49 35<br>124 59 | 28 | 2.0 | .65 | 50 | 880<br>.95 | 0.3 | 25<br>4.0 | 700 | 3200 | 3.9 | 2.5<br>6.0 |
| TSABLE R<br>T10 | 49 31<br>124 54 | 97 | 6.8 | .65 | 50 | 500<br>1.4 | 0.0 | 25<br>4.0 | 2400 | 4200 | 1.5 | 1.0<br>2.2 |
| TUGWELL CR<br>T11 | 48 25<br>123 50 | 13 | .65 | .51 | 50 | 625<br>.59 | 0.3 | 25<br>5.0 | 230 | 1200 | 5.6 | 2.6<br>12 |
| UCONA R<br>U41 | 49 44<br>125 57 | 66 | 6.6 | .65 | 50 | 200<br>1.1 | 0.0 | 138<br>10 | 2300 | 3200 | 1.2 | 0.8<br>1.7 |
| UNNAMED CR<br>U19 | 50 04<br>126 11 | 11 | .80 | .64 | 90 | 1200<br>.65 | 10 | 138<br>12 | 530 | 3800 | 6.3 | 3.9<br>10 |
| UNNAMED CR<br>U33 | 49 23<br>126 04 | 8 | .77 | .65 | 40 | 300<br>.57 | 1.5 | 25<br>17 | 220 | 1400 | 5.3 | 3.3<br>8.7 |
| UNNAMED CR<br>U5 | 50 08<br>127 11 | 30 | 2.3 | .64 | 30 | 500<br>.99 | 4.5 | 25<br>38 | 490 | 3400 | 6.0 | 3.7<br>9.7 |
| UNNAMED CR<br>U30 | 49 27<br>126 05 | 6 | .57 | .65 | 40 | 220<br>.48 | 2.0 | 25<br>30 | 160 | 1200 | 6.3 | 3.9<br>10 |
| UNNAMED CR<br>U2 | 50 29<br>127 21 | 15 | 1.2 | .65 | 90 | 600<br>.65 | 3.0 | 25<br>10 | 770 | 2100 | 2.4 | 1.4<br>4.0 |
| UNNAMED CR<br>U31 | 49 24<br>126 17 | 4 | .38 | .65 | 40 | 150<br>.41 | 1.5 | 25<br>29 | 110 | 930 | 7.2 | 4.4<br>12 |
| UNNAMED CR<br>U4 | 50 18<br>127 12 | 13 | 1.0 | .65 | 90 | 600<br>.62 | 5.0 | 25<br>27 | 670 | 2200 | 2.9 | 1.6<br>5.2 |
| UNNAMED CR<br>U21 | 49 57<br>126 25 | 18 | 1.8 | .65 | 30 | 170<br>.74 | 2.5 | 138<br>9.0 | 380 | 1700 | 3.7 | 2.3<br>6.1 |
| UNNAMED CR<br>U26 | 49 48<br>126 25 | 12 | 1.2 | .65 | 30 | 200<br>.65 | 0.6 | 138<br>0.5 | 250 | 1300 | 4.3 | 2.6<br>7.0 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNNAMED CR<br>U6 | 49 52<br>127 05 | 11 | 1.1 | .65 | 60 | 720<br>.71 | 1.2 | 25<br>30 | 480 | 2300 | 4.1 | 2.8<br>6.1 |
| UNNAMED CR<br>U12 | 50 10<br>126 20 | 10 | .74 | .64 | 244 | 1450<br>.54 | 2.0 | 138<br>13 | 1300 | 3000 | 2.1 | 1.3<br>3.3 |
| UNNAMED CR<br>U9 | 50 21<br>126 07 | 19 | 1.2 | .64 | 120 | 1000<br>.68 | 1.5 | 25<br>19 | 1000 | 2800 | 2.4 | 1.3<br>4.6 |
| UNNAMED CR<br>U32 | 49 52<br>126 50 | 7.3 | 1.0 | .65 | 30 | 350<br>.69 | 1.0 | 25<br>19 | 220 | 1600 | 6.0 | 3.9<br>9.3 |
| UNNAMED CR<br>U22 | 49 55<br>126 48 | 3.5 | .49 | .65 | 30 | 90<br>.44 | 7.0 | 25<br>9.0 | 110 | 1500 | 11 | 7.4<br>17 |
| UNNAMED CR<br>U29 | 49 29<br>126 14 | 17 | 1.7 | .65 | 80 | 400<br>.72 | 2.0 | 25<br>30 | 980 | 2200 | 1.9 | 1.2<br>3.1 |
| UNNAMED CR<br>U23 | 49 23<br>126 07 | 4 | .41 | .65 | 40 | 400<br>.48 | 1.5 | 25<br>13 | 110 | 1300 | 9.3 | 5.7<br>15 |
| UNNAMED CR<br>U27 | 49 47<br>126 44 | 10 | 1.5 | .65 | 60 | 1150<br>.87 | 3.0 | 138<br>19 | 640 | 4400 | 6.0 | 3.9<br>9.2 |
| UNNAMED CR<br>U16 | 50 07<br>126 36 | 14 | 1.7 | .65 | 120 | 1000<br>.78 | 8.0 | 138<br>9.0 | 1400 | 4100 | 2.4 | 1.5<br>3.8 |
| UNNAMED CR<br>U10 | 50 20<br>126 26 | 19 | 1.1 | .64 | 120 | 1000<br>.67 | 14 | 138<br>23 | 1000 | 4300 | 3.8 | 2.0<br>7.3 |
| UNNAMED CR<br>U1 | 50 29<br>122 22 | 15 | 1.2 | .65 | 180 | 1850<br>.71 | 3.0 | 25<br>8.0 | 1500 | 4100 | 2.3 | 1.3<br>4.0 |
| UNNAMED CR<br>U17 | 50 05<br>126 25 | 27 | 2.0 | .64 | 60 | 1250<br>.99 | 0.0 | 138<br>0.8 | 890 | 5000 | 5.0 | 3.1<br>8.1 |
| UNNAMED CR<br>U13 | 50 10<br>126 37 | 17 | 2.0 | .65 | 90 | 1200<br>.92 | 1.0 | 138<br>7.0 | 1300 | 4700 | 3.1 | 1.9<br>4.8 |
| UNNAMED CR<br>U40 | 49 46<br>125 41 | 33 | 2.5 | .65 | 200 | 1060<br>.83 | 13 | 138<br>20 | 3500 | 6100 | 1.5 | 0.9<br>2.6 |
| UNNAMED CR<br>U28 | 49 39<br>126 04 | 14 | 1.4 | .65 | 40 | 100<br>.59 | 5.0 | 25<br>5.0 | 400 | 1800 | 3.9 | 2.4<br>6.3 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNNAMED CR<br>U7 | 50 30<br>126 54 | 22 | 1.4 | .68 | 60 | 500<br>.73 | 0.8 | 138<br>1.6 | 620 | 2000 | 2.6 | 1.4<br>4.8 |
| UNNAMED CR<br>U34 | 49 21<br>126 01 | 4 | .37 | .65 | 40 | 250<br>.44 | 4.5 | 25<br>16 | 110 | 1400 | 11 | 6.6<br>17 |
| UNNAMED CR<br>U14 | 50 10<br>126 18 | 19 | 1.4 | .64 | 90 | 800<br>.74 | 1.3 | 138<br>14 | 940 | 2600 | 2.5 | 1.5<br>4.0 |
| UNNAMED CR<br>U38 | 50 11<br>125 24 | 19 | .80 | .67 | 100 | 1400<br>.65 | 10 | 25<br>9.0 | 570 | 3900 | 5.7 | 2.8<br>12 |
| UNNAMED CR<br>U15 | 50 08<br>126 37 | 18 | 2.2 | .65 | 60 | 675<br>.91 | 1.8 | 138<br>11 | 960 | 3500 | 3.1 | 2.0<br>4.9 |
| UNNAMED CR<br>U11 | 50 13<br>126 05 | 12 | .90 | .64 | 55 | 900<br>.69 | 1.5 | 25<br>13 | 350 | 2500 | 6.3 | 3.9<br>10 |
| UNNAMED CR<br>U18 | 50 05<br>126 28 | 20 | 1.5 | .64 | 90 | 1320<br>.83 | 1.5 | 138<br>1.2 | 980 | 4600 | 4.1 | 2.5<br>6.7 |
| UNNAMED CR<br>U20 | 49 57<br>126 51 | 3 | .43 | .65 | 122 | 700<br>.44 | 0.0 | 25<br>5.0 | 380 | 1400 | 3.2 | 2.1<br>4.9 |
| UNNAMED CR<br>U39 | 49 50<br>125 38 | 25 | .90 | .65 | 50 | 375<br>.61 | 2.0 | 138<br>14 | 320 | 1500 | 4.1 | 2.3<br>7.2 |
| UNNAMED CR<br>U35 | 49 19<br>126 05 | 4 | .41 | .65 | 80 | 550<br>.44 | 0.7 | 25<br>4.5 | 230 | 1300 | 4.8 | 3.0<br>7.8 |
| UNNAMED CR<br>U8 | 50 29<br>126 24 | 21 | 1.3 | .64 | 152 | 1250<br>.70 | 10 | 138<br>33 | 1380 | 4400 | 2.8 | 1.5<br>5.3 |
| UNNAMED CR<br>U25 | 49 48<br>126 17 | 20 | 2.0 | .65 | 30 | 400<br>.90 | 0.5 | 138<br>1.5 | 430 | 2300 | 4.5 | 2.8<br>7.3 |
| UNNAMED CR<br>U36 | 49 17<br>126 10 | 8 | .84 | .65 | 40 | 600<br>.67 | 2.5 | 25<br>6.5 | 240 | 2100 | 7.6 | 4.7<br>12 |
| UNNAMED CR<br>U37 | 49 17<br>126 10 | 8 | .79 | .67 | 40 | 375<br>.60 | 2.5 | 25<br>6.5 | 220 | 1600 | 6.0 | 3.7<br>9.7 |
| UPANA CR<br>U24 | 49 48<br>126 05 | 58 | 5.8 | .65 | 30 | 800<br>1.5 | 0.1 | 138<br>0.1 | 1300 | 5900 | 4.1 | 2.5<br>6.7 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UTLUH CR<br>U3 | 50 19<br>127 25 | 19 | 1.5 | .65 | 60 | 920<br>.84 | 10 | 25<br>10 | 640 | 4200 | 5.7 | 3.2<br>10 |
| WADY CR<br>W1 | 50 24<br>127 17 | 15 | 1.2 | .65 | 180 | 825<br>.61 | 6.5 | 25<br>16 | 1500 | 3000 | 1.7 | 1.0<br>2.9 |
| WALT LAKE CR<br>W5 | 49 53<br>124 08 | 14 | .70 | .65 | 150 | 600<br>.49 | 0.5 | 25<br>16 | 750 | 1500 | 1.8 | 0.8<br>3.8 |
| WARD CR<br>W2 | 49 47<br>126 04 | 8.5 | .86 | .65 | 30 | 200<br>.58 | 0.4 | 138<br>0.4 | 180 | 1000 | 4.8 | 3.0<br>7.8 |
| WHITE R<br>W4 | 50 18<br>125 56 | 350 | 17.5 | .67 | 50 | 950<br>2.2 | 0.0 | 25<br>2.0 | 6300 | 13000 | 1.7 | 0.9<br>3.2 |
| WILFRED CR<br>W6 | 49 28<br>124 51 | 20 | 1.5 | .62 | 50 | 313<br>.71 | 0.0 | 25<br>3.5 | 540 | 1400 | 2.4 | 1.2<br>4.6 |
| WILSON CR<br>W3 | 49 39<br>126 10 | 14 | 1.4 | .65 | 40 | 400<br>.76 | 1.0 | 25<br>11 | 400 | 1900 | 4.1 | 2.5<br>6.6 |
| YOOKWA CR<br>Y1 | 50 04<br>126 28 | 34 | 2.5 | .64 | 30 | 800<br>1.1 | 1.5 | 138<br>3.0 | 550 | 4400 | 7.0 | 4.3<br>11 |
| ZEBALLOS L<br>Z2 | 50 03<br>126 46 | 45 | 5.4 | .65 | 90 | 1250<br>1.3 | 2.3 | 25<br>10 | 3500 | 7800 | 1.9 | 1.2<br>3.0 |
| ZEBALLOS R<br>Z1 | 50 03<br>126 47 | 47 | 5.6 | .65 | 60 | 800<br>1.3 | 0.0 | 25<br>10 | 2400 | 5800 | 2.1 | 1.3<br>3.2 |
| ZEBALLOS(LITTLE) R<br>Z3 | 49 59<br>126 45 | 9 | 1.5 | .65 | 210 | 750<br>.64 | 0.4 | 25<br>6.0 | 2300 | 2620 | 1.0 | 0.6<br>1.7 |

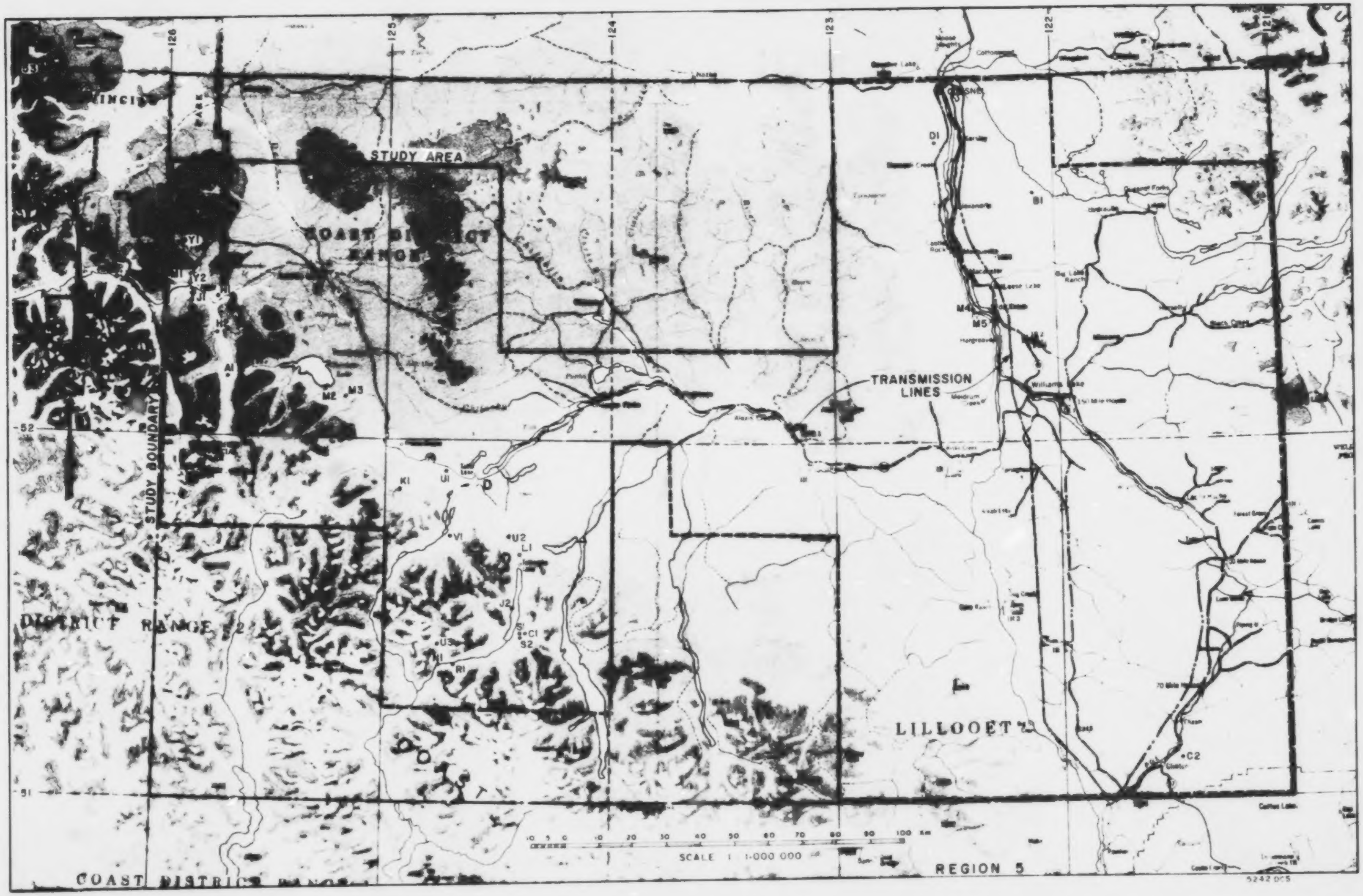

N
STUDY AREA
STUDY AREA
STUDY BOUNDARY
TRANSMISSION LINES
KAMLOOPS
DIVISION OF YALE
I.D 10
M O N S
SCALE 1:1,000,000
10 5 0 10 20 30 40 50 60 70 80 90 100 Km
REGION 4
53
52
51
120
119
118
117
116
A1
A2
A3
A4
A5
B1
C1
C2
C3
C4
C5
C6
C7
C8
D1
D2
D3
D4
D5
G1
G2
G3
H1
H2
K1
K2
M1
M2
M3
M4
M5
O1
P2
P3
R1
S1
U1
U2
U3
Y1

5242 DCS

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADOLPH CR #1<br>A4 | 52 31<br>119 23 | 80 | 2.8 | .50 | 213 | 3400<br>1.1 | 6.0 | 25<br>29 | 4300 | 13600 | 3.6 | 2.0<br>6.5 |
| ADOLPH CR #2<br>A5 | 52 31<br>119 24 | 78 | 2.7 | .50 | 61 | 700<br>1.0 | 6.0 | 25<br>29 | 1200 | 4200 | 4.0 | 2.2<br>7.2 |
| ALLAN CR<br>A3 | 52 32<br>119 07 | 122 | 4.3 | .50 | 91 | 1900<br>1.3 | 2.0 | 25<br>12 | 2800 | 9300 | 3.8 | 2.1<br>6.7 |
| AZURE R #1<br>A1 | 52 35<br>119 48 | 98 | 3.4 | .50 | 61 | 800<br>1.1 | 31 | 25<br>60 | 1500 | 8400 | 6.4 | 3.6<br>11 |
| AZURE R #2<br>A2 | 52 32<br>119 47 | 228 | 8.0 | .50 | 30 | 900<br>1.8 | 28 | 25<br>60 | 1700 | 11500 | 7.5 | 4.2<br>13 |
| BULLDOG CR<br>B1 | 52 39<br>118 59 | 104 | 3.6 | .50 | 152 | 875<br>.97 | 18 | 25<br>26 | 3900 | 7100 | 2.0 | 1.1<br>3.7 |
| CAMP CR<br>C6 | 52 39<br>119 11 | 74 | 2.6 | .50 | 91 | 1100<br>.98 | 2.0 | 25<br>2.0 | 1700 | 4700 | 3.2 | 1.8<br>5.7 |
| CANIM FALLS<br>C1 | 51 53<br>120 35 | N/A | 18 | .44 | N/A | N/A<br>N/A | 0.8 | 25<br>0.8 | N/A | N/A | N/A | N/A<br>N/A |
| CHUA CHUA CR<br>C5 | 51 21<br>120 07 | 104 | .50 | .43 | 450 | 1900<br>.44 | 2.0 | 25<br>2.0 | 1500 | 3100 | 2.7 | 1.6<br>4.4 |
| CIRQUE CR<br>C8 | 51 26<br>117 06 | 20 | .40 | .52 | 123 | 700<br>.44 | 5.0 | 25<br>2.0 | 360 | 1900 | 5.6 | 2.1<br>15 |
| CLEARWATER RAPID-1<br>C2 | 51 49<br>120 03 | N/A | 210 | .44 | N/A | N/A<br>N/A | 0.0 | 25<br>N/A | N/A | N/A | N/A | N/A<br>N/A |
| CLEARWATER RAPID-2<br>C3 | 51 41<br>120 02 | N/A | 225 | .44 | N/A | N/A<br>N/A | 0.0 | 25<br>N/A | N/A | N/A | N/A | N/A<br>N/A |
| CLEARWATER RAPID-3<br>C4 | 51 39<br>120 04 | N/A | 227 | .44 | N/A | N/A<br>N/A | 0.0 | 25<br>1.0 | N/A | N/A | N/A | N/A<br>N/A |
| CLEMINA CR<br>C7 | 52 34<br>119 05 | 70 | 2.5 | .50 | 152 | 1300<br>.90 | 2.0 | 25<br>10 | 2700 | 5000 | 2.1 | 1.2<br>3.9 |
| DAVE HENRY CR #1<br>D4 | 52 46<br>119 04 | 92 | 3.2 | .50 | 61 | 850<br>1.1 | 3.0 | 25<br>15 | 1400 | 4600 | 3.7 | 2.1<br>6.7 |

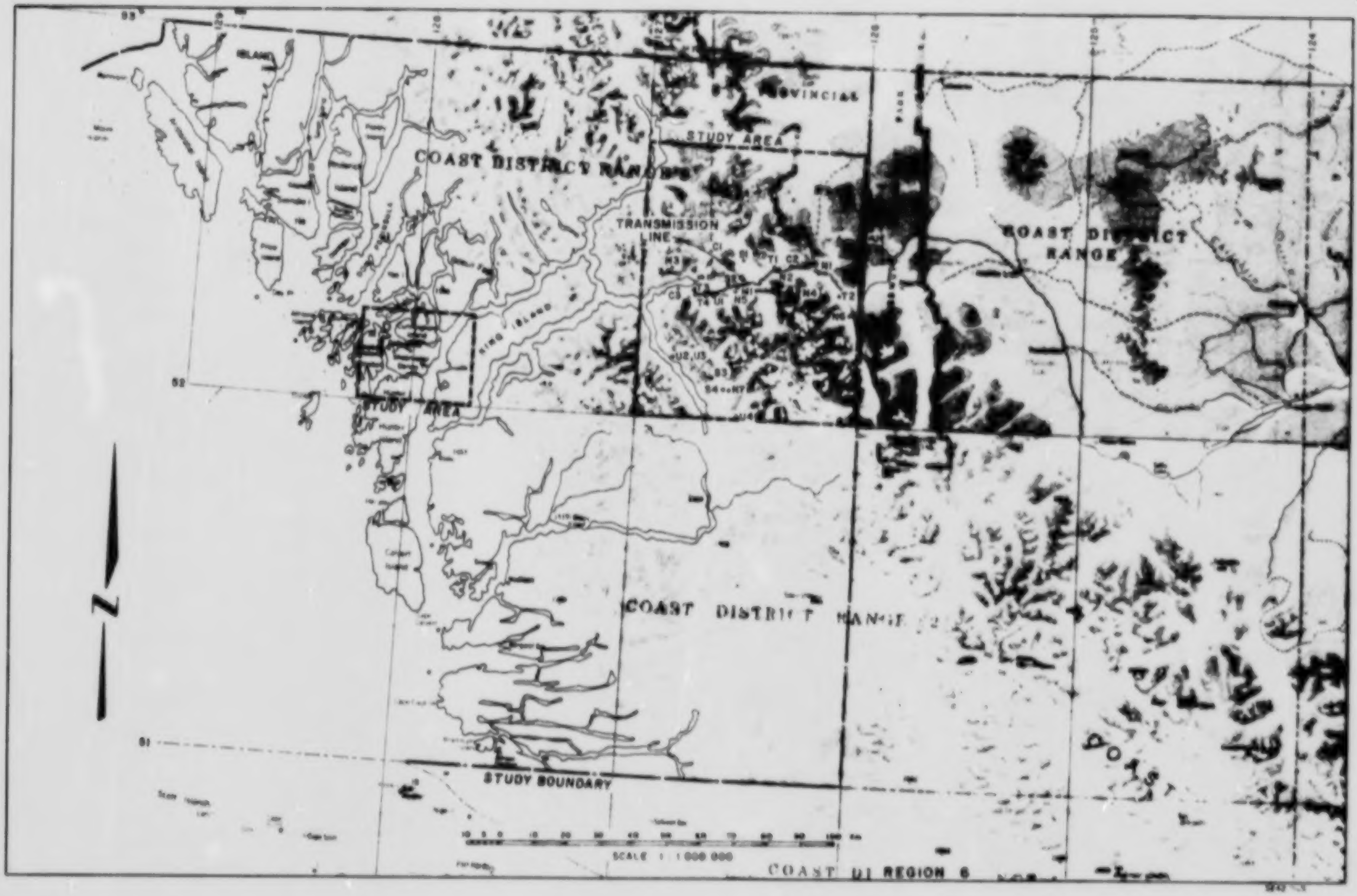
| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAVE HENRY CR #2<br>D5 | 52 45<br>119 05 | 99 | 3.5 | .50 | 91 | 550<br>.97 | 5.5 | 25<br>11 | 2300 | 4000 | 2.0 | 1.1<br>3.6 |
| DAWSON FALLS<br>D1 | 51 58<br>120 08 | 1378 | 44 | .44 | N/A | N/A<br>N/A | 0.0 | 25<br>22 | N/A | N/A | N/A | N/A<br>N/A |
| DEADMAN R @ FALLS<br>D3 | 51 09<br>120 51 | 246 | .60 | .43 | N/A | N/A<br>N/A | 1.0 | 25<br>24 | N/A | N/A | N/A | N/A<br>N/A |
| DECEPTION FALLS<br>D2 | 51 54<br>120 28 | N/A | 34 | .44 | N/A | N/A<br>N/A | 0.8 | 25<br>5.5 | N/A | N/A | N/A | N/A<br>N/A |
| GHITA CR<br>G3 | 52 51<br>118 39 | 76 | 2.7 | .50 | 306 | 2750<br>.94 | 3.0 | 25<br>31 | 5800 | 11500 | 2.2 | 1.3<br>4.0 |
| GOODWIN FALLS<br>G1 | 51 55<br>120 13 | 4714 | 30 | .44 | N/A | N/A<br>N/A | 0.5 | 25<br>15 | N/A | N/A | N/A | N/A<br>N/A |
| GRANT BROOK<br>G2 | 52 54<br>118 45 | 111 | 3.9 | .50 | 152 | 1500<br>1.1 | 2.0 | 25<br>21 | 4200 | 6900 | 1.8 | 1.0<br>3.3 |
| GRIZZLY CR<br>G4 | 51 19<br>117 25 | 75 | 3.0 | .52 | 305 | 3400<br>1.0 | 7.0 | 25<br>50 | 6500 | 16800 | 2.8 | 1.1<br>7.4 |
| HELMCKEN FALLS<br>H1 | 51 57<br>120 10 | 1384 | 45 | .44 | N/A | N/A<br>N/A | 0.3 | 25<br>19 | N/A | N/A | N/A | N/A<br>N/A |
| HOLT CR<br>H2 | 51 20<br>117 01 | 42 | .80 | .52 | 92 | 1500<br>.68 | 5.0 | 25<br>3.0 | 550 | 3600 | 7.0 | 2.7<br>19 |
| KICKING HORSE FALL<br>K2 | 51 11<br>116 34 | N/A | N/A | N/A | N/A | N/A<br>N/A | 1.0 | 25<br>30 | N/A | N/A | N/A | N/A<br>N/A |
| KIMMEL CR<br>K1 | 52 43<br>119 25 | 47.5 | 1.7 | .50 | 91 | 820<br>.79 | 11 | 25<br>10 | 1100 | 4000 | 4.1 | 2.3<br>7.4 |
| McLENNAN R @ N.ARM<br>M3 | 52 51<br>119 21 | 95 | 3.3 | .50 | 61 | 1250<br>1.2 | 6.0 | 25<br>5.5 | 1460 | 6600 | 5.2 | 2.9<br>9.3 |
| McLENNAN R<br>M4 | 52 50<br>119 20 | 139 | 4.9 | .50 | 30 | 800<br>1.4 | 2.5 | 25<br>4.0 | 1070 | 5800 | 6.2 | 3.4<br>11 |
| McLENNON R @S.ARM<br>M2 | 52 51<br>119 21 | 40 | 1.4 | .50 | 244 | 1450<br>.69 | 5.0 | 25<br>6.0 | 2500 | 4100 | 1.9 | 1.0<br>3.5 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MOOSE R<br>M5 | 52 55<br>118 48 | 464 | 16 | .50 | 61 | 550<br>1.8 | 0.8 | 25<br>15 | 6800 | 7700 | 1.3 | 0.9<br>1.9 |
| MUSHROOM RAPIDS<br>M1 | 51 58<br>120 08 | 1378 | 44 | .44 | N/A | N/A<br>N/A | 0.0 | 25<br>22 | N/A | N/A | N/A | N/A<br>N/A |
| OLDMAN CR<br>O1 | 51 29<br>117 15 | 24 | .50 | .52 | 123 | 750<br>.46 | 6.0 | 25<br>5.0 | 420 | 2100 | 5.3 | 2.0<br>14 |
| PACKSADDLE CR<br>P2 | 52 48<br>119 08 | 46 | 1.6 | .50 | 122 | 1250<br>.80 | 4.0 | 25<br>7.5 | 1400 | 3760 | 3.0 | 1.8<br>5.3 |
| PETERSON CR<br>P1 | 51 12<br>120 10 | 125 | .30 | .43 | 100 | 300<br>.36 | 0.3 | 25<br>3.0 | 230 | 770 | 4.5 | 2.8<br>7.3 |
| PTARMIGAN CR<br>P3 | 52 35<br>118 50 | 272 | 9.5 | .50 | 61 | 1600<br>1.8 | 2.5 | 25<br>40 | 4100 | 12800 | 3.5 | 2.0<br>6.3 |
| RAPIDS ON MURTLE R<br>R1 | 51 59<br>120 06 | 1370 | 43 | .44 | N/A | N/A<br>N/A | 0.0 | 25<br>23 | N/A | N/A | N/A | N/A<br>N/A |
| SKULL CR<br>S2 | 51 09<br>120 13 | 70 | .18 | .43 | 100 | 250<br>.30 | 1.0 | 25<br>7.0 | 130 | 700 | 6.8 | 3.3<br>14 |
| SWIFT CR #1<br>S3 | 52 52<br>119 13 | 110 | 3.3 | .50 | 91 | 1325<br>1.1 | 6.0 | 25<br>5.0 | 2100 | 6500 | 3.4 | 2.3<br>5.2 |
| SWIFT CR #2<br>S4 | 52 51<br>119 16 | 126 | 3.7 | .50 | 61 | 1425<br>1.3 | 2.1 | 25<br>0.9 | 1600 | 7100 | 5.0 | 3.3<br>7.5 |
| SYLVIA FALLS<br>S1 | 51 55<br>120 13 | 4714 | 30 | .44 | N/A | N/A<br>N/A | 0.5 | 25<br>15 | N/A | N/A | N/A | N/A<br>N/A |
| UNNAMED CR<br>U1 | 52 56<br>118 53 | 75 | 2.6 | .50 | 366 | 1420<br>.80 | 4.0 | 25<br>11 | 6800 | 7500 | 1.2 | 0.7<br>2.2 |
| UNNAMED CR<br>U2 | 52 55<br>118 53 | 74 | 2.6 | .50 | 184 | 330<br>.71 | 4.0 | 25<br>11 | 3450 | 3100 | 1.0 | 0.6<br>1.8 |
| UNNAMED CR<br>U3 | 52 54<br>118 46 | 71 | 2.5 | .50 | 152 | 520<br>.77 | 2.5 | 25<br>24 | 2700 | 2880 | 1.2 | 0.7<br>2.1 |
| YELLOWJACKET CR<br>Y1 | 52 43<br>119 03 | 94 | 3.3 | .50 | 61 | 400<br>.96 | 0.8 | 25<br>17 | 1400 | 2800 | 2.3 | 1.3<br>4.0 |


STUDY AREA
COAST DISTRICT RANGE
STUDY BOUNDARY
PARK
TRANSMISSION LINES
Williams Lake
150 Mile House
70 Mile House
Cotton Lake
LILLOOET
DISTRICT RANGE 2
COAST DISTRICT RANGE
REGION 5
126
125
124
123
122
121
53
52
51
D1
B1
M4
M5
M2
M3
A1
Y1
Y2
K1
U1
V1
U2
L1
J2
S1
C1
S2
U3
R1
C2
10 5 0 10 20 30 40 50 60 70 80 90 100 km
SCALE 1:1 000 000
5242 DCS

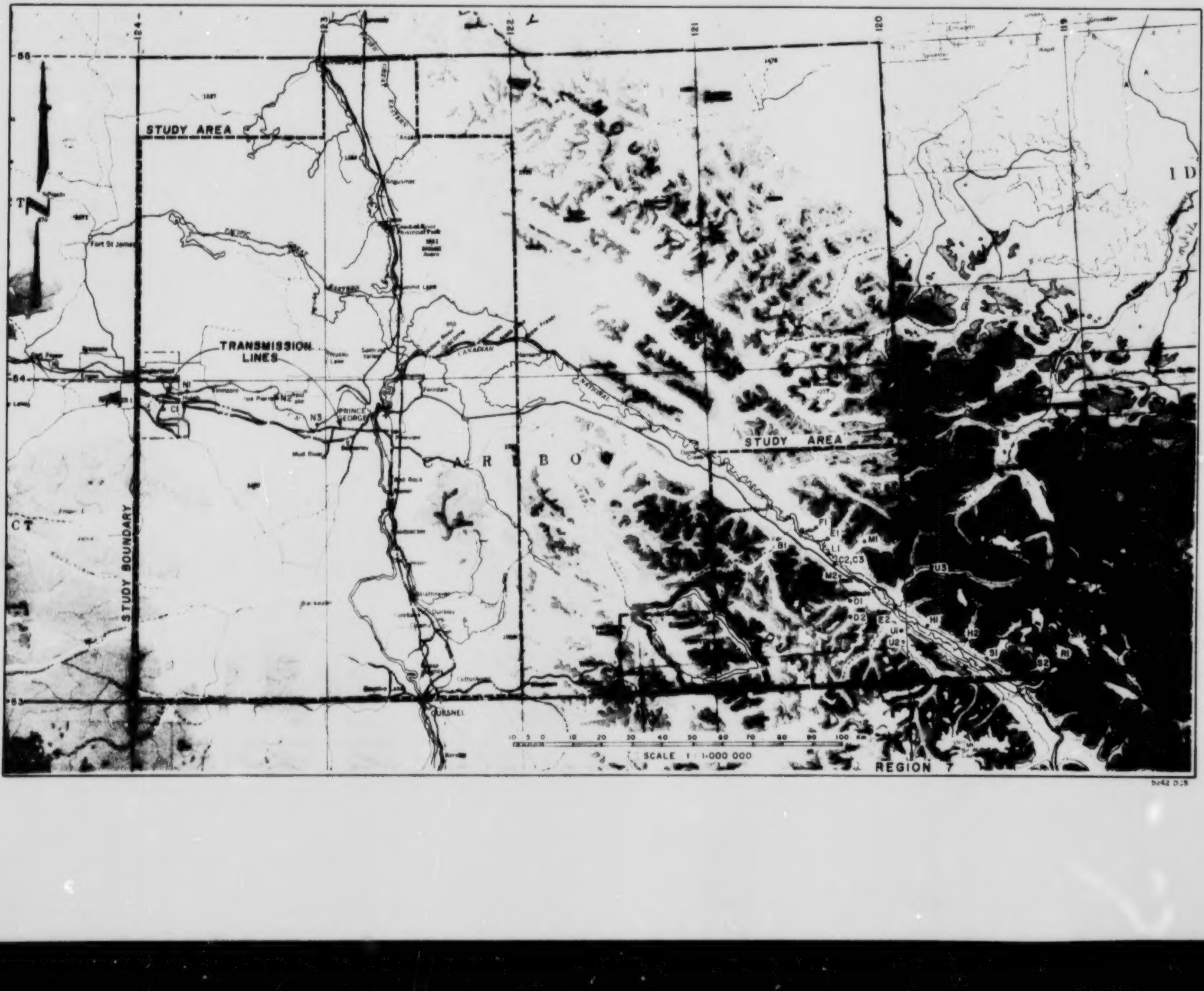
| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ATNARKO R<br>A1 | 52 10<br>125 42 | 689 | 10 | .60 | 275 | 3400<br>1.7 | 35 | 25<br>52 | 20000 | 46000 | 2.2 | 1.4<br>3.3 |
| BEAVER CR @ FALLS<br>B1 | 52 41<br>122 06 | 1200 | 3.0 | .43 | N/A | N/A<br>N/A | 2.0 | 25<br>18 | N/A | N/A | N/A | N/A<br>N/A |
| CHESHI CR<br>C1 | 51 28<br>124 22 | 40 | .80 | .45 | 92 | 450<br>.54 | 5.0 | 25<br>22 | 530 | 1970 | 4.7 | 1.7<br>13 |
| CLINTON FALLS<br>C2 | 51 07<br>121 29 | 250 | .40 | .44 | N/A | N/A<br>N/A | 0.0 | 25<br>4.0 | N/A | N/A | N/A | N/A<br>N/A |
| DESERTERS CR<br>D1 | 52 49<br>122 32 | 105 | .50 | .37 | 100 | 220<br>.41 | 2.0 | 25<br>2.0 | 380 | 1100 | 4.2 | 2.0<br>8.6 |
| HOTNARKO R<br>H1 | 52 23<br>125 45 | 514 | 7.7 | .60 | 153 | 2250<br>1.5 | 15 | 25<br>30 | 8500 | 18000 | 2.0 | 1.0<br>4.0 |
| HUNLEN CR<br>H2 | 52 17<br>125 45 | 117 | 2.8 | .65 | 521 | 1200<br>.76 | 2.0 | 25<br>48 | 10500 | 8800 | 0.7 | 0.5<br>1.1 |
| JAMISON CR<br>J2 | 51 32<br>124 26 | 42 | .40 | .45 | 396 | 3400<br>.47 | 17 | 25<br>15 | 1200 | 6600 | 7.0 | 2.0<br>25 |
| JANET CR<br>J1 | 52 23<br>125 52 | 38 | 1.0 | .65 | 610 | 1950<br>.53 | 4.0 | 25<br>32 | 4100 | 6600 | 1.4 | 0.6<br>3.0 |
| KLINAKLINI CR<br>K1 | 51 52<br>124 56 | 98 | 2.5 | .45 | 61 | 650<br>.94 | 11 | 25<br>11 | 1070 | 4700 | 5.5 | 2.4<br>12 |
| LINCOLN CR<br>L1 | 51 41<br>124 24 | 14 | .10 | .45 | 213 | 1500<br>.31 | 3.0 | 25<br>2.0 | 220 | 1600 | 9.0 | 2.6<br>32 |
| MACKIN CR<br>M4 | 52 22<br>122 23 | 480 | .50 | .45 | 250 | 2000<br>.49 | 0.3 | 25<br>2.0 | 860 | 2700 | 3.9 | 1.5<br>10 |
| MAYDOE CR<br>M2 | 52 08<br>125 16 | 51 | .70 | .60 | 213 | 3250<br>.62 | 17 | 25<br>35 | 1030 | 7620 | 7.0 | 3.6<br>14 |
| McCLINCHY CR<br>M3 | 52 07<br>125 10 | 208 | 3.1 | .60 | 30 | 800<br>1.2 | 10 | 25<br>33 | 670 | 5740 | 8.0 | 4.2<br>16 |
| MCLEESE CR<br>M5 | 52 20<br>122 17 | 150 | .30 | .45 | 150 | 1300<br>.45 | 0.0 | 25<br>0.0 | 360 | 1740 | 6.0 | 3.5<br>10 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MOSHER CR<br>M1 | 52 25<br>125 58 | 42 | 1.1 | .65 | 457 | 2400<br>.60 | 3.0 | 25<br>32 | 3450 | 6700 | 1.7 | 0.8<br>3.7 |
| NUDE CR FALLS<br>N1 | 51 23<br>124 45 | 188 | 7.5 | .50 | N/A | N/A<br>N/A | 22 | 25<br>54 | N/A | N/A | N/A | N/A<br>N/A |
| RELIANCE CR<br>R1 | 51 23<br>124 41 | 42 | 1.7 | .50 | 92 | 350<br>.68 | 17 | 25<br>50 | 1100 | 4000 | 4.1 | 1.9<br>8.7 |
| STIKELAN CR #1<br>S1 | 51 28<br>124 24 | 192 | 4.8 | .45 | 31 | 450<br>1.3 | 1.5 | 25<br>22 | 1070 | 4200 | 4.9 | 1.9<br>13 |
| STIKELAN CR #2<br>S2 | 51 27<br>124 22 | 110 | 3.3 | .45 | 91 | 900<br>1.0 | 6.0 | 25<br>25 | 2100 | 5300 | 3.1 | 1.1<br>8.5 |
| UNNAMED CR<br>U1 | 51 55<br>124 44 | 60 | .50 | .40 | 61 | 750<br>.53 | 1.0 | 25<br>1.0 | 210 | 1600 | 11 | 4.0<br>28 |
| UNNAMED CR<br>U3 | 51 26<br>124 45 | 27 | 1.1 | .50 | 336 | 1350<br>.58 | 30 | 25<br>60 | 2600 | 7430 | 3.3 | 1.5<br>7.0 |
| UNNAMED CR<br>U2 | 51 44<br>124 27 | 43 | .40 | .45 | 425 | 3700<br>.47 | 4.0 | 25<br>1.0 | 1310 | 5300 | 5.1 | 1.5<br>18 |
| VALLEAU CR<br>V1 | 51 44<br>124 43 | 120 | 1.2 | .45 | 92 | 1050<br>.73 | 2.0 | 25<br>25 | 790 | 3010 | 4.8 | 1.8<br>13 |
| YOUNG CR<br>Y2 | 52 25<br>125 53 | 230 | 5.5 | .65 | 457 | 2500<br>1.1 | 3.0 | 25<br>32 | 18000 | 23000 | 1.1 | 0.5<br>2.5 |
| YOUNG CR @ RAPIDS<br>Y1 | 52 32<br>125 54 | 83 | 1.2 | .60 | 61 | 900<br>.78 | 7.0 | 25<br>20 | 540 | 3500 | 6.0 | 3.1<br>12 |


COAST DISTRICT RANGE
PROVINCIAL
STUDY AREA
TRANSMISSION LINE
COAST DISTRICT RANGE
STUDY AREA
COAST DISTRICT RANGE
COAST
STUDY BOUNDARY
SCALE 1 : 1 000 000
COAST DI REGION 6
N
52
51
53

| BC SMALL HYDRO ASSESSMENT | LAT LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CACOOHTIN CR<br>C2 | 52 26<br>126 19 | 42 | 1.7 | .65 | 214 | 1200<br>.73 | 3.0 | 25<br>2.0 | 2590 | 3600 | 1.2 | 0.6<br>2.5 |
| CHRISTENSON CR<br>C1 | 52 28<br>126 41 | 40 | 2.8 | .65 | 91 | 1400<br>1.1 | 15 | 25<br>12 | 1830 | 7620 | 3.6 | 2.0<br>6.6 |
| CLAYTON FALLS CR<br>C3 | 52 22<br>126 49 | 83 | 6.6 | .65 | 61 | 700<br>1.4 | 1.0 | 25<br>0.0 | 2900 | 5500 | 1.6 | 1.0<br>2.7 |
| MILL CR<br>M1 | 52 24<br>126 34 | 15 | 1.1 | .65 | 638 | 2200<br>.56 | 0.0 | 25<br>1.5 | 4800 | 6800 | 1.2 | 0.8<br>2.1 |
| NIEUMIAMUS CR<br>N3 | 52 25<br>126 51 | 29 | 2.5 | .65 | 61 | 1450<br>1.1 | 4.0 | 25<br>10 | 1080 | 6400 | 5.2 | 3.2<br>8.3 |
| NOEICK R<br>N7 | 52 05<br>126 34 | 232 | 14 | .65 | 122 | 2150<br>2.0 | 6.0 | 25<br>56 | 12200 | 24100 | 1.7 | 0.9<br>3.4 |
| NOOMST CR #1<br>N4 | 52 23<br>126 15 | 53 | 1.3 | .65 | 427 | 2950<br>.69 | 12 | 25<br>7.0 | 4070 | 9950 | 2.1 | 1.0<br>4.6 |
| NOOMST CR #2<br>N1 | 52 26<br>126 13 | 96 | 3.4 | .65 | 61 | 550<br>1.0 | 3.0 | 25<br>1.0 | 1480 | 3600 | 2.1 | 1.2<br>3.9 |
| NOOSGULCH CR<br>N2 | 52 26<br>126 23 | 125 | 8.4 | .65 | 30 | 700<br>1.7 | 2.0 | 25<br>1.0 | 1800 | 6500 | 3.1 | 1.9<br>5.3 |
| NOOKLIKONNIK CR<br>N5 | 52 22<br>126 34 | 31 | 1.7 | .65 | 366 | 2400<br>.75 | 5.0 | 25<br>2.0 | 4480 | 7900 | 1.5 | 0.9<br>2.8 |
| NORDSCHOW CR<br>N6 | 52 18<br>126 03 | 96 | 2.9 | .65 | 183 | 1500<br>.95 | 10 | 25<br>20 | 3790 | 7030 | 1.6 | 0.8<br>3.2 |
| SALLOOMT CR<br>S1 | 52 27<br>126 32 | 135 | 8.6 | .65 | 31 | 850<br>1.8 | 1.0 | 25<br>7.0 | 1910 | 7300 | 3.3 | 2.3<br>4.9 |
| SMITELY R @ FALLS<br>S4 | 52 05<br>126 36 | 265 | 18.6 | .65 | 31 | 450<br>2.1 | 3.0 | 25<br>56 | 4100 | 9300 | 2.0 | 1.1<br>3.6 |
| SMITELY R<br>S3 | 52 07<br>126 39 | 213 | 15 | .65 | 61 | 400<br>1.7 | 8.0 | 25<br>61 | 6500 | 8000 | 1.1 | 0.6<br>1.9 |
| SNOOTLI CR<br>S2 | 52 23<br>126 36 | 34 | 2.2 | .65 | 152 | 1250<br>.86 | 2.0 | 25<br>0.5 | 2420 | 4530 | 1.6 | 1.0<br>2.8 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TASTSQUAN CR<br>T3 | 52 22<br>126 45 | 25 | 1.9 | .65 | 91 | 250<br>.67 | 0.5 | 25<br>0.5 | 1200 | 1730 | 1.2 | 0.8<br>2.0 |
| THORSEN CR<br>T4 | 52 21<br>126 42 | 80 | 6.1 | .65 | 80 | 1550<br>1.5 | 1.0 | 25<br>1.0 | 3500 | 8830 | 2.2 | 1.4<br>3.6 |
| TSEAPSEAHOOLZ CR<br>T1 | 52 26<br>126 24 | 25 | 1.3 | .65 | 274 | 1900<br>.68 | 5.0 | 25<br>0.5 | 2470 | 4730 | 1.7 | 0.9<br>3.1 |
| TSINI-TSINI CR<br>T2 | 52 22<br>126 06 | 39 | 1.2 | .65 | 213 | 1450<br>.66 | 5.0 | 25<br>12 | 1790 | 3800 | 1.9 | 1.0<br>3.6 |
| UNNAMED CR<br>U2 | 52 10<br>126 50 | 46 | 3.2 | .65 | 152 | 1050<br>.96 | 1.5 | 25<br>31 | 3500 | 5000 | 1.3 | 0.7<br>2.3 |
| UNNAMED CR<br>U3 | 52 10<br>126 50 | 42 | 2.9 | .65 | 396 | 3200<br>.96 | 4.0 | 25<br>31 | 8400 | 18000 | 1.9 | 1.0<br>3.4 |
| UNNAMED CR<br>U4 | 52 01<br>126 32 | 68 | 4.1 | .65 | 214 | 1300<br>1.0 | 16 | 25<br>61 | 6280 | 9000 | 1.3 | 0.6<br>2.4 |
| UNNAMED CR<br>U1 | 52 21<br>126 40 | 5 | .40 | .65 | 1036 | 2700<br>.41 | 4.0 | 25<br>0.5 | 2800 | 7700 | 2.4 | 1.4<br>3.9 |

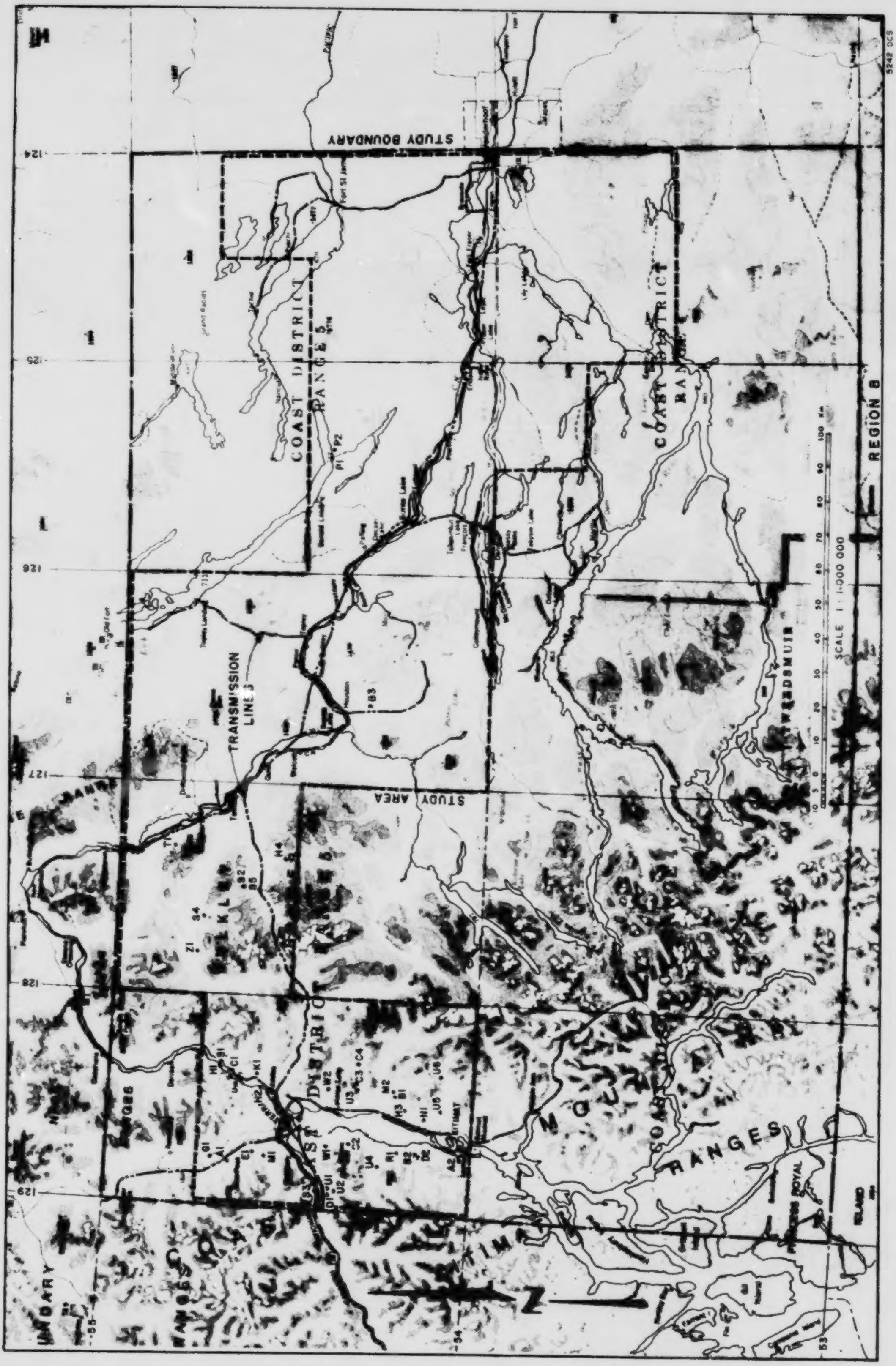


55
54
53
124
123
122
121
120
119
STUDY AREA
STUDY AREA
STUDY BOUNDARY
TRANSMISSION LINES
PRINCE GEORGE
QUESNEL
Fort St James
CARIBOO
ID
CT
N
N1
N2
N3
C1
F1
E1
M1
B1
L1
C2,C3
M2
U3
D1
D2
E2
U1
U2
H1
H2
S1
S2
R1
10 5 0 10 20 30 40 50 60 70 80 90 100 Km
SCALE 1 : 1 000 000
REGION 7

5242 D.8

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOUNDING CR<br>B1 | 53 28<br>120 39 | 16 | .50 | .50 | 92 | 800<br>.52 | 5.0 | 25<br>37 | 350 | 2200 | 7.0 | 4.5<br>11 |
| CARROLE FALLS<br>C1 | 53 58<br>123 51 | N/A | N/A | .40 | N/A | N/A<br>N/A | 0.5 | 25<br>1.5 | N/A | N/A | N/A | N/A<br>N/A |
| CLYDE CR #1<br>C2 | 53 23<br>120 22 | 30 | 1.1 | .50 | 183 | 2250<br>.70 | 3.0 | 25<br>15 | 1400 | 4800 | 4.0 | 2.5<br>6.2 |
| CLYDE CR #2<br>C3 | 5[illegible] [illegible]<br>120 [illegible] | 30 | 1.1 | .50 | 91 | 900<br>.68 | 3.0 | 25<br>16 | 690 | 2600 | 4.2 | 2.7<br>6.6 |
| DORE R #1<br>D1 | 53 16<br>120 17 | 178 | 6.8 | .50 | 92 | 1600<br>1.5 | 1.7 | 25<br>13 | 4450 | 10300 | 2.6 | 1.8<br>3.9 |
| DORE R #2<br>D2 | 53 13<br>120 17 | 137 | 5.2 | .50 | 91 | 1500<br>1.4 | 6.0 | 25<br>17 | 3420 | 8830 | 2.9 | 2.0<br>4.3 |
| EAST TWIN CR<br>E1 | 53 28<br>120 23 | 112 | 3.9 | .50 | 61 | 300<br>.98 | 2.0 | 25<br>22 | 1720 | 3000 | 2.0 | 1.2<br>3.1 |
| EDDY CR<br>E2 | 53 14<br>120 07 | 20 | .70 | .50 | 213 | 1000<br>.51 | 3.0 | 25<br>10 | 1070 | 2330 | 2.5 | 1.6<br>3.9 |
| FLEET CR<br>F1 | 53 30<br>120 27 | 58 | 2.0 | .50 | 91 | 1500<br>.95 | 10 | 25<br>32 | 1300 | 6800 | 5.9 | 3.8<br>9.2 |
| HOLLIDAY CR<br>H1 | 53 11<br>119 53 | 52 | 1.8 | .50 | 91 | 1400<br>.90 | 3.0 | 25<br>28 | 1190 | 5100 | 4.8 | 3.0<br>7.7 |
| HORSEY CR<br>H2 | 53 08<br>119 41 | 168 | 5.9 | .50 | 122 | 2050<br>1.4 | 5.0 | 25<br>14 | 5150 | 11500 | 2.6 | 1.4<br>4.6 |
| LEGRAND CR<br>L1 | 53 25<br>120 23 | 13 | .50 | .50 | 152 | 1150<br>.49 | 2.0 | 25<br>22 | 550 | 2100 | 4.4 | 2.8<br>6.8 |
| McINTOSH CR<br>M2 | 53 21<br>120 20 | 33 | 1.2 | .50 | 92 | 800<br>.69 | 2.5 | 25<br>12 | 760 | 2430 | 3.6 | 2.3<br>5.8 |
| McKALE R<br>M1 | 53 27<br>120 12 | 31 | 1.1 | .50 | 183 | 1600<br>.66 | 11 | 25<br>25 | 1380 | 4700 | 3.9 | 2.6<br>5.7 |
| NECHAKO R RAPIDS<br>N3 | 53 52<br>123 03 | N/A | 350 | .50 | N/A | N/A<br>N/A | 1.0 | 60<br>1.5 | N/A | N/A | N/A | N/A<br>N/A |

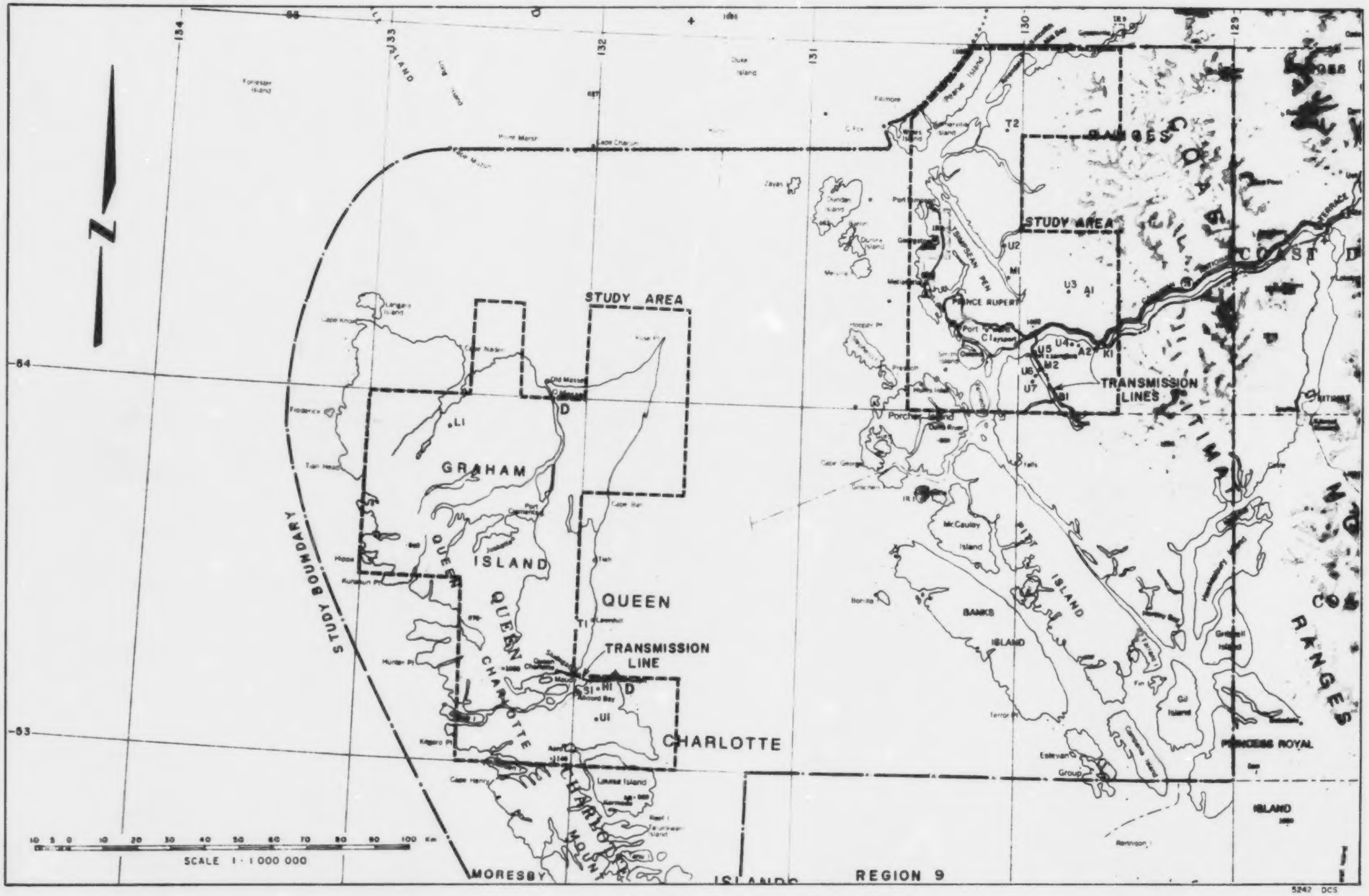
| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NECHAKO R RAPIDS<br>N1 | 53 58<br>123 43 | N/A | 200 | .50 | N/A | N/A<br>N/A | 0.5 | 25<br>4.0 | N/A | N/A | N/A | N/A<br>N/A |
| NECHAKO R RAPIDS<br>N2 | 53 57<br>123 15 | N/A | 328 | .50 | N/A | N/A<br>N/A | 0.0 | 25<br>9.0 | N/A | N/A | N/A | N/A<br>N/A |
| ROBSON R<br>R1 | 53 03<br>119 13 | 175 | 6.1 | .50 | 61 | 1050<br>1.5 | 1.0 | 25<br>2.5 | 2690 | 7030 | 3.0 | 1.7<br>5.3 |
| SMALL CR<br>S1 | 53 04<br>119 35 | 261 | 9.1 | .50 | 61 | 1400<br>1.8 | 5.0 | 25<br>7.0 | 4000 | 11050 | 3.1 | 1.8<br>5.6 |
| SWIFTCURRENT CR<br>S2 | 53 01<br>119 17 | 165 | 5.8 | .50 | 61 | 800<br>1.4 | 2.0 | 25<br>0.5 | 2550 | 5730 | 2.6 | 1.4<br>4.6 |
| UNNAMED CR<br>U2 | 53 08<br>120 01 | 27 | .90 | .50 | 335 | 1300<br>.55 | 14 | 25<br>23 | 2240 | 4700 | 2.4 | 1.5<br>3.7 |
| UNNAMED CR<br>U3 | 53 21<br>119 51 | 36 | 1.3 | .50 | 274 | 2000<br>.69 | 34 | 25<br>32 | 2490 | 9300 | 4.2 | 2.7<br>6.7 |
| UNNAMED CR<br>U1 | 53 10<br>120 02 | 13 | .50 | .50 | 549 | 1700<br>.41 | 12 | 25<br>18 | 1830 | 4440 | 2.8 | 1.8<br>4.4 |


STUDY BOUNDARY
COAST DISTRICT
RANGE 5
COAST DISTRICT
RANGE
TRANSMISSION LINE 3
STUDY AREA
BULKLEY RANGES
DISTRICT
KITIMAT
RANGES
TWEEDSMUIR
PRINCESS ROYAL
N
SCALE 1:1 000 000
0 10 20 30 40 50 60 70 80 90 100 km
REGION 8
124
125
126
127
128
129
55
54
53
5242 DCS

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALICE CR<br>A1 | 54 40<br>128 47 | 35 | 1.9 | .60 | 92 | 1200<br>.89 | 2.0 | 138<br>1.0 | 1250 | 4000 | 3.0 | 1.8<br>5.0 |
| ANDERSON CR<br>A2 | 54 02<br>128 43 | 34 | 2.6 | .60 | 61 | 900<br>1.0 | 1.0 | 25<br>5.0 | 1140 | 3710 | 3.1 | 1.9<br>5.0 |
| BOLTON CR<br>B1 | 54 13<br>128 26 | 64 | 4.8 | .60 | 61 | 1050<br>1.3 | 8.0 | 25<br>18 | 2100 | 6600 | 3.0 | 1.8<br>4.9 |
| BOWBYES CR<br>B2 | 54 09<br>128 42 | 19 | 1.4 | .60 | 122 | 800<br>.70 | 3.0 | 25<br>8.0 | 1230 | 2400 | 1.9 | 1.1<br>3.1 |
| BUCK CR<br>B3 | 54 20<br>126 37 | 485 | 3.7 | .50 | 50 | 900<br>1.2 | 1.0 | 25<br>2.3 | 1300 | 4850 | 4.2 | 2.3<br>7.4 |
| CHIST CR #1<br>C3 | 54 19<br>128 24 | 63 | 3.4 | .60 | 31 | 700<br>1.2 | 12 | 138<br>13 | 740 | 5100 | 6.5 | 4.1<br>10 |
| CHIST CR #2<br>C4 | 54 19<br>128 18 | 50 | 2.7 | .60 | 61 | 975<br>1.0 | 16 | 138<br>16 | 1180 | 5900 | 4.7 | 2.9<br>7.6 |
| CHIMDEMASH CR<br>C1 | 54 40<br>128 22 | 82 | 4.5 | .60 | 122 | 2500<br>1.3 | 3.0 | 25<br>0.0 | 3950 | 10400 | 2.5 | 1.6<br>4.0 |
| COLDWATER CR<br>C2 | 54 20<br>128 40 | 51 | 2.8 | .60 | 91 | 1825<br>1.1 | 6.0 | 25<br>7.5 | 1840 | 7100 | 3.7 | 2.3<br>5.9 |
| DAHL CR<br>D2 | 54 09<br>128 43 | 32 | 2.4 | .60 | 91 | 600<br>.86 | 1.0 | 25<br>10 | 1580 | 2700 | 1.6 | 1.0<br>2.7 |
| DASQUE CR<br>D1 | 54 23<br>128 55 | 68 | 3.7 | .60 | 61 | 920<br>1.2 | 14 | 25<br>16 | 1600 | 6010 | 3.5 | 2.2<br>5.7 |
| ERLANDSEN CR<br>E1 | 54 36<br>128 44 | 74 | 4.0 | .60 | 61 | 1500<br>1.3 | 1.5 | 25<br>9.0 | 1750 | 6710 | 3.7 | 2.3<br>5.8 |
| GOAT CR<br>G1 | 54 43<br>128 46 | 31 | 1.7 | .60 | 91 | 675<br>.77 | 1.0 | 138<br>4.0 | 1120 | 2210 | 1.9 | 1.2<br>3.0 |
| HANKIN CR<br>H2 | 54 35<br>128 26 | 18 | 1.0 | .60 | 91 | 950<br>.67 | 9.0 | 25<br>1.0 | 660 | 3100 | 4.4 | 2.7<br>7.3 |
| HARDSCRABBLE CR<br>H1 | 54 42<br>128 20 | 53 | 2.9 | .60 | 61 | 350<br>.90 | 8.0 | 25<br>8.0 | 1270 | 3300 | 2.4 | 1.5<br>3.9 |

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOWSON CR<br>H4 | 554 33<br>127 21 | 140 | 2.0 | .50 | 50 | 700<br>.91 | 8.0 | 25<br>28 | 700 | 3900 | 6.2 | 3.1<br>13 |
| HUMPHRYS CR<br>H3 | 54 11<br>128 30 | 19 | 1.4 | .60 | 122 | 1900<br>.82 | 3.0 | 25<br>13 | 1230 | 5050 | 3.9 | 2.4<br>6.5 |
| KLEANZA CR<br>K1 | 54 36<br>128 22 | 168 | 9.2 | .60 | 92 | 1200<br>1.6 | 2.0 | 25<br>2.0 | 6060 | 8900 | 1.4 | 0.9<br>2.2 |
| McKAY CR<br>M2 | 54 13<br>128 25 | 65 | 4.9 | .60 | 152 | 2750<br>1.4 | 8.0 | 25<br>18 | 5370 | 13100 | 2.3 | 1.4<br>3.8 |
| MOLYBDENUM CR<br>M1 | 54 34<br>128 45 | 19 | 1.0 | .60 | 152 | 1100<br>.63 | 1.0 | 25<br>8.5 | 1090 | 2300 | 2.0 | 1.1<br>3.3 |
| NABEELAH CR<br>N1 | 54 08<br>128 32 | 19 | 1.4 | .60 | 92 | 900<br>.75 | 2.0 | 25<br>6.0 | 920 | 2500 | 2.5 | 1.5<br>4.2 |
| PINKUT CR FALLS #1<br>P1 | 54 27<br>125 27 | 862 | 6.0 | .43 | 31 | 400<br>N/A | 0.0 | 25<br>30 | 1300 | 4200 | 4.0 | 2.5<br>6.2 |
| PINKUT CR FALLS #2<br>P2 | 54 26<br>125 25 | 862 | 6.0 | .43 | N/A | N/A<br>N/A | 0.0 | 25<br>30 | N/A | N/A | N/A | N/A<br>N/A |
| RALEY CR<br>R1 | 54 12<br>128 42 | 19 | 1.5 | .60 | 91 | 1250<br>.82 | 3.0 | 25<br>15 | 980 | 3900 | 3.7 | 2.3<br>6.0 |
| SERB CR RAPIDS<br>S4 | 54 46<br>127 38 | 155 | 2.2 | .50 | N/A | N/A<br>N/A | 4.0 | 25<br>28 | N/A | N/A | N/A | N/A<br>N/A |
| SHAMES R<br>S3 | 54 25<br>128 54 | 78 | 4.3 | .60 | 61 | 1320<br>1.3 | 0.0 | 25<br>15 | 1880 | 6060 | 3.1 | 1.9<br>4.9 |
| SHANNON CR<br>S2 | 54 40<br>127 30 | 28 | 1.5 | .60 | 122 | 1200<br>.77 | 5.0 | 25<br>17 | 1300 | 3400 | 2.4 | 1.5<br>1.3 |
| SINCLAIR CR<br>S5 | 54 37<br>127 30 | 48 | .70 | .50 | 100 | 1500<br>.62 | 1.5 | 25<br>17 | 480 | 3000 | 6.9 | 3.7<br>1.3 |
| STE CROIX<br>S1 | 54 42<br>128 19 | 31 | 1.7 | .60 | 122 | 1400<br>.83 | 1.4 | 25<br>6.0 | 1490 | 4050 | 2.6 | 1.6<br>4.1 |
| TROUT CR<br>T1 | 54 51<br>127 19 | 115 | 1.6 | .60 | 50 | 500<br>.79 | 0.0 | 25<br>0.0 | 570 | 1910 | 3.8 | 1.8<br>7.9 |

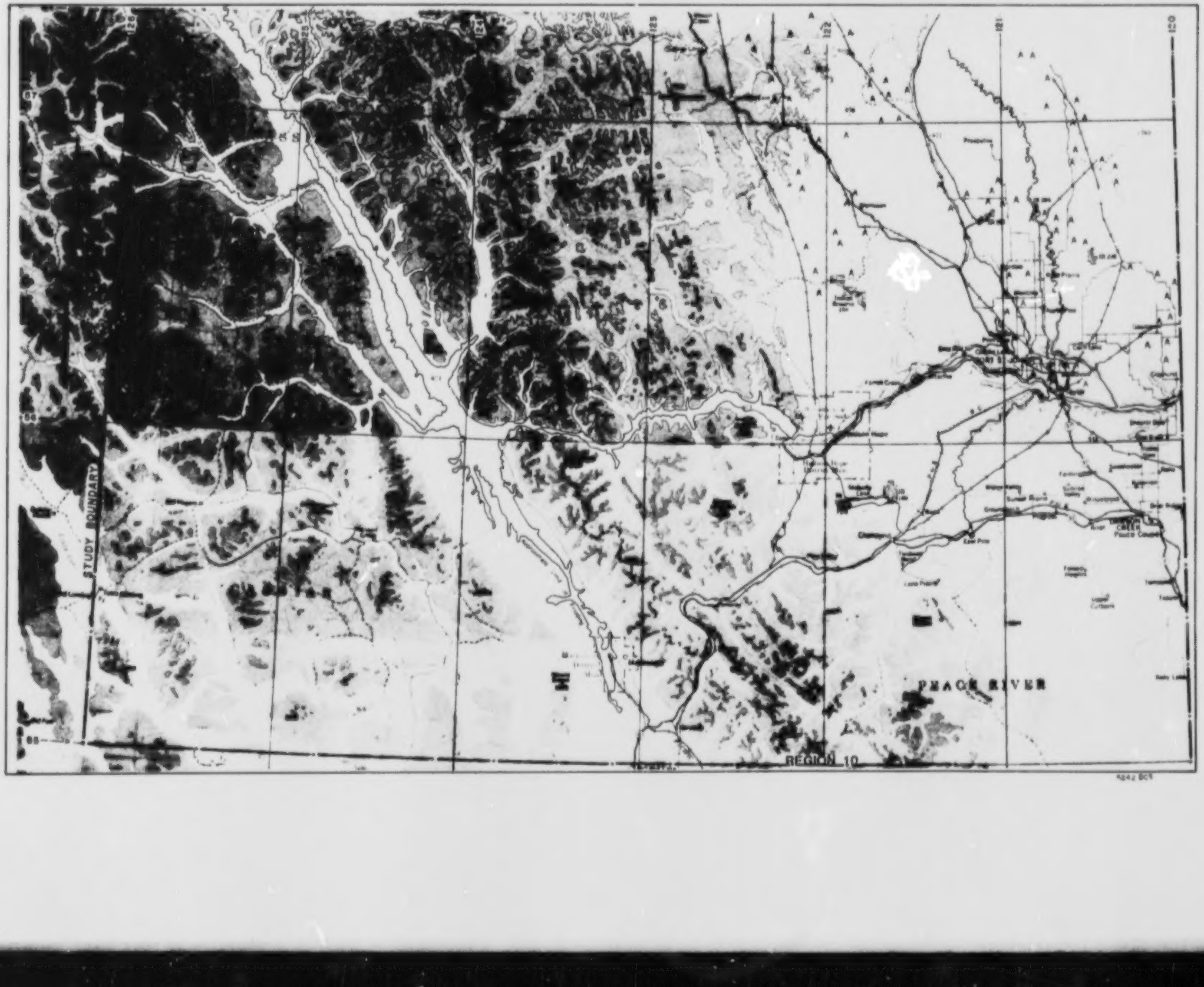
| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNNAMED CR<br>U4 | 54 15<br>128 46 | 10 | .70 | .60 | 122 | 800<br>.54 | 7.0 | 25<br>21 | 610 | 2340 | 3.6 | 2.0<br>6.6 |
| UNNAMED CR<br>U1 | 54 23<br>128 53 | 26 | 1.4 | .60 | 183 | 1250<br>.70 | 13 | 25<br>15 | 1800 | 4440 | 2.3 | 1.4<br>3.8 |
| UNNAMED CR<br>U5 | 54 05<br>128 30 | 13 | 1.0 | .60 | 61 | 950<br>.73 | 4.0 | 25<br>5.0 | 440 | 2600 | 5.5 | 3.4<br>9.1 |
| UNNAMED CR<br>U3 | 54 19<br>128 24 | 1.2 | 1.2 | .60 | 91 | 850<br>.70 | 8.0 | 138<br>10 | 790 | 3000 | 3.6 | 2.3<br>5.7 |
| UNNAMED CR<br>U2 | 54 22<br>128 54 | 41 | 2.2 | .60 | 122 | 2100<br>.99 | 13 | 25<br>15 | 1900 | 7920 | 3.9 | 2.4<br>6.3 |
| UNNAMED CR<br>U6 | 54 05<br>128 20 | 34 | 2.6 | .60 | 91 | 900<br>.95 | 15 | 25<br>22 | 1700 | 5500 | 3.0 | 1.9<br>4.9 |
| WHITE CR<br>W1 | 54 24<br>128 41 | 23 | 1.3 | .60 | 152 | 1750<br>.75 | 5.0 | 25<br>8.0 | 1390 | 4020 | 2.7 | 1.7<br>4.3 |
| WILLIAMS CR<br>W2 | 54 24<br>128 25 | 136 | 7.5 | .60 | 61 | 1100<br>1.6 | 4.0 | 25<br>6.0 | 3290 | 7510 | 2.2 | 1.4<br>3.5 |
| ZYMOETZ R<br>Z1 | 54 47<br>127 49 | 600 | 8.4 | .50 | N/A | N/A<br>N/A | 3.0 | 25<br>38 | N/A | N/A | N/A | N/A<br>N/A |

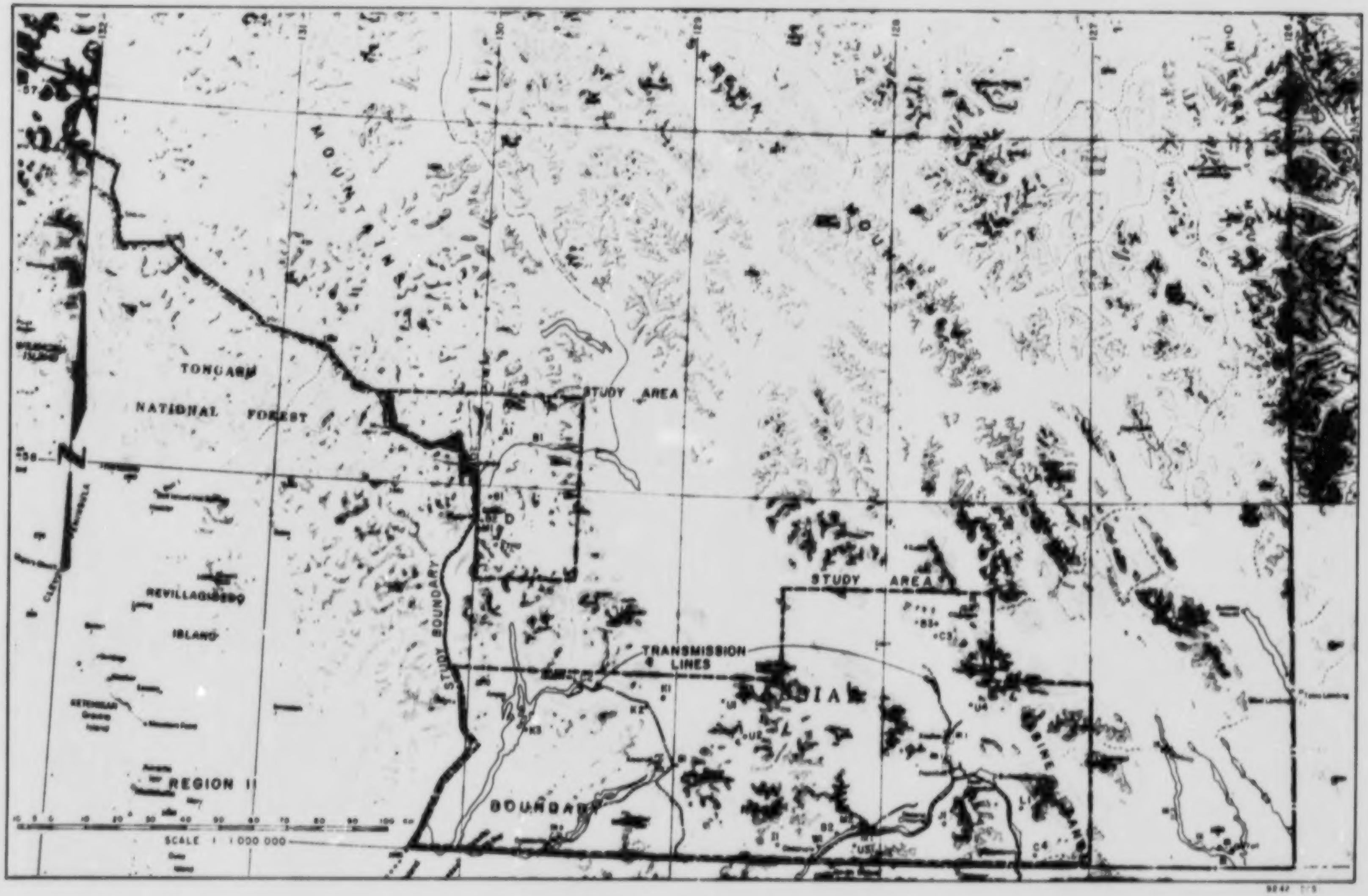

STUDY AREA
STUDY AREA
TRANSMISSION LINES
TRANSMISSION LINE
STUDY BOUNDARY
GRAHAM
ISLAND
QUEEN
QUEEN CHARLOTTE
QUEEN
CHARLOTTE
ISLANDS
MORESBY
CHARLOTTE
REGION 9
PRINCE RUPERT
TSIMPSEAN PEN
Port Clements
Old Massett
Porcher Island
McCauley Island
PITT ISLAND
BANKS ISLAND
Gil Island
PRINCESS ROYAL ISLAND
Terrace
COAST RANGES
KITIMAT RANGES
T1
T2
U1
U2
U3
U4
U5
U6
U7
A1
A2
K1
M1
M2
B1
C1
D
D
S1
H1
L1
54
53
129
130
131
132
133
134
SCALE 1 : 1 000 000
10 5 0 10 20 30 40 50 60 70 80 90 100 Km
N

5242 DCS

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ARDEN CR<br>A1 | 54 19<br>129 41 | 12 | 1.2 | .70 | 336 | 750<br>.55 | 15 | 25<br>16 | 2900 | 4500 | 1.3 | 0.8<br>2.1 |
| AYTON CR<br>A2 | 54 11<br>129 43 | 45 | 4.5 | .70 | 31 | 400<br>1.2 | 3.0 | 230<br>6.0 | 1000 | 3830 | 3.1 | 1.7<br>5.8 |
| BROWN CR<br>B1 | 54 02<br>129 50 | 56 | 6.0 | .72 | 107 | 500<br>1.1 | 1.0 | 69<br>3.0 | 4660 | 4400 | 0.7 | 0.5<br>1.2 |
| COLONEL JOHNSON CR<br>C1 | 54 13<br>130 09 | 3 | .30 | .70 | 276 | 800<br>.36 | 3.0 | 69<br>5.0 | 610 | 1530 | 2.0 | 1.1<br>3.8 |
| HAANS CR SANDSPIT<br>H1 | 53 13<br>131 53 | 21 | 1.5 | .65 | 62 | 1900<br>.95 | 4.0 | 25<br>4.0 | 650 | 6600 | 8.9 | 5.3<br>15 |
| KHTADA CR<br>K1 | 54 11<br>129 36 | 150 | 15 | .70 | 62 | 900<br>2.0 | 1.0 | 230<br>0.5 | 6690 | 9800 | 1.2 | 0.7<br>2.0 |
| LIGNITE CR<br>L1 | 53 55<br>132 37 | 67 | 4.7 | .65 | 61 | 1000<br>1.3 | 7.0 | 25<br>35 | 2060 | 6940 | 3.0 | 1.8<br>4.9 |
| MARION CR<br>M1 | 54 22<br>130 03 | 10 | 1.0 | .70 | 122 | 1600<br>.70 | 3.0 | 230<br>20 | 870 | 3610 | 3.4 | 1.8<br>6.3 |
| McDONALD CR<br>M2 | 54 07<br>129 54 | 12 | 1.2 | .70 | 315 | 1900<br>.64 | 2.5 | 69<br>0.5 | 2600 | 4600 | 1.4 | 0.8<br>2.7 |
| SACHS CR<br>S1 | 53 12<br>131 58 | 17 | 1.2 | .65 | 91 | 850<br>.70 | 0.0 | 25<br>5.0 | 780 | 2400 | 2.7 | 1.6<br>4.4 |
| TALA HAAT CR<br>T2 | 54 46<br>130 04 | 36 | 3.1 | .65 | 30 | 300<br>1.0 | 5.0 | 12.5<br>5.0 | 660 | 3030 | 4.0 | 2.1<br>7.7 |
| TLELL R<br>T1 | 53 22<br>132 00 | 31 | 2.2 | .65 | 30 | 600<br>1.0 | 14 | 25<br>14 | 470 | 4700 | 8.8 | 5.3<br>15 |
| UNNAMED CR<br>U7 | 54 05<br>129 56 | 38 | 3.8 | .70 | 30 | 400<br>1.2 | 3.5 | 69<br>12 | 820 | 3460 | 3.4 | 1.9<br>6.1 |
| UNNAMED CR<br>U5 | 54 10<br>129 56 | 1 | .10 | .70 | 650 | 2000<br>.23 | 3.0 | 69<br>0.5 | 490 | 1900 | 3.1 | 1.7<br>5.9 |
| UNNAMED CR<br>U1 | 53 08<br>131 53 | 19 | 1.3 | .70 | 30 | 600<br>.84 | 2.5 | 25<br>11 | 280 | 2800 | 8.0 | 4.7<br>13 |

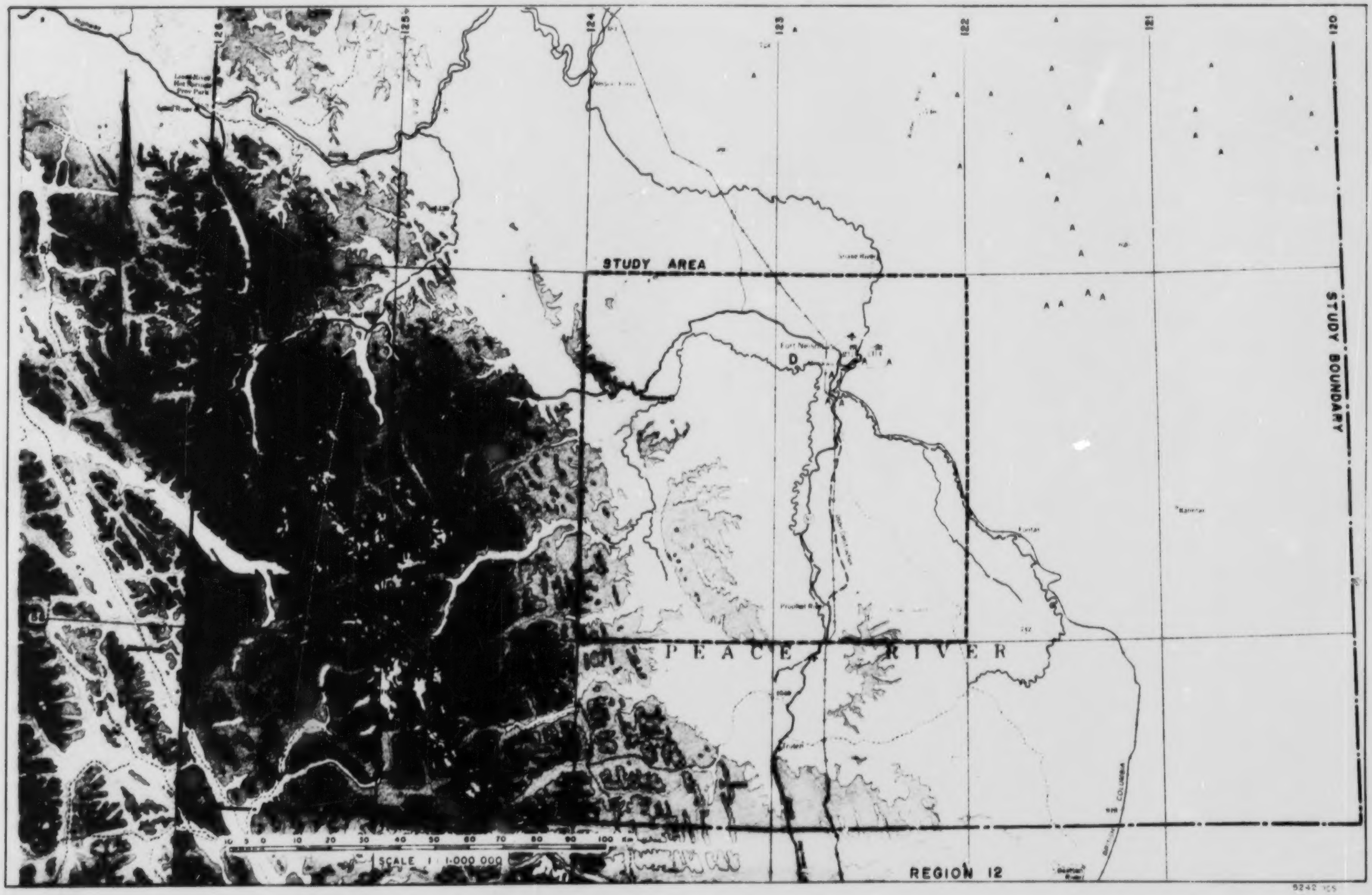
| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNNAMED CR<br>U2 | 54 27<br>130 04 | 6 | .60 | .70 | 274 | 1100<br>.47 | 2.0 | 230<br>30 | 1180 | 2200 | 1.5 | 0.6<br>4.1 |
| UNNAMED CR<br>U6 | 54 06<br>129 55 | 56 | 5.6 | .70 | 31 | 600<br>1.4 | 2.5 | 69<br>12 | 1250 | 5100 | 3.3 | 2.1<br>5.4 |
| UNNAMED CR<br>U3 | 54 20<br>129 46 | 7 | .70 | .70 | 397 | 800<br>.45 | 15 | 25<br>16 | 2000 | 3940 | 1.6 | 1.0<br>2.6 |
| UNNAMED CR<br>U4 | 54 11<br>129 45 | 15 | 1.5 | .70 | 122 | 1300<br>.78 | 3.0 | 230<br>10 | 1300 | 3720 | 2.3 | 1.2<br>4.3 |

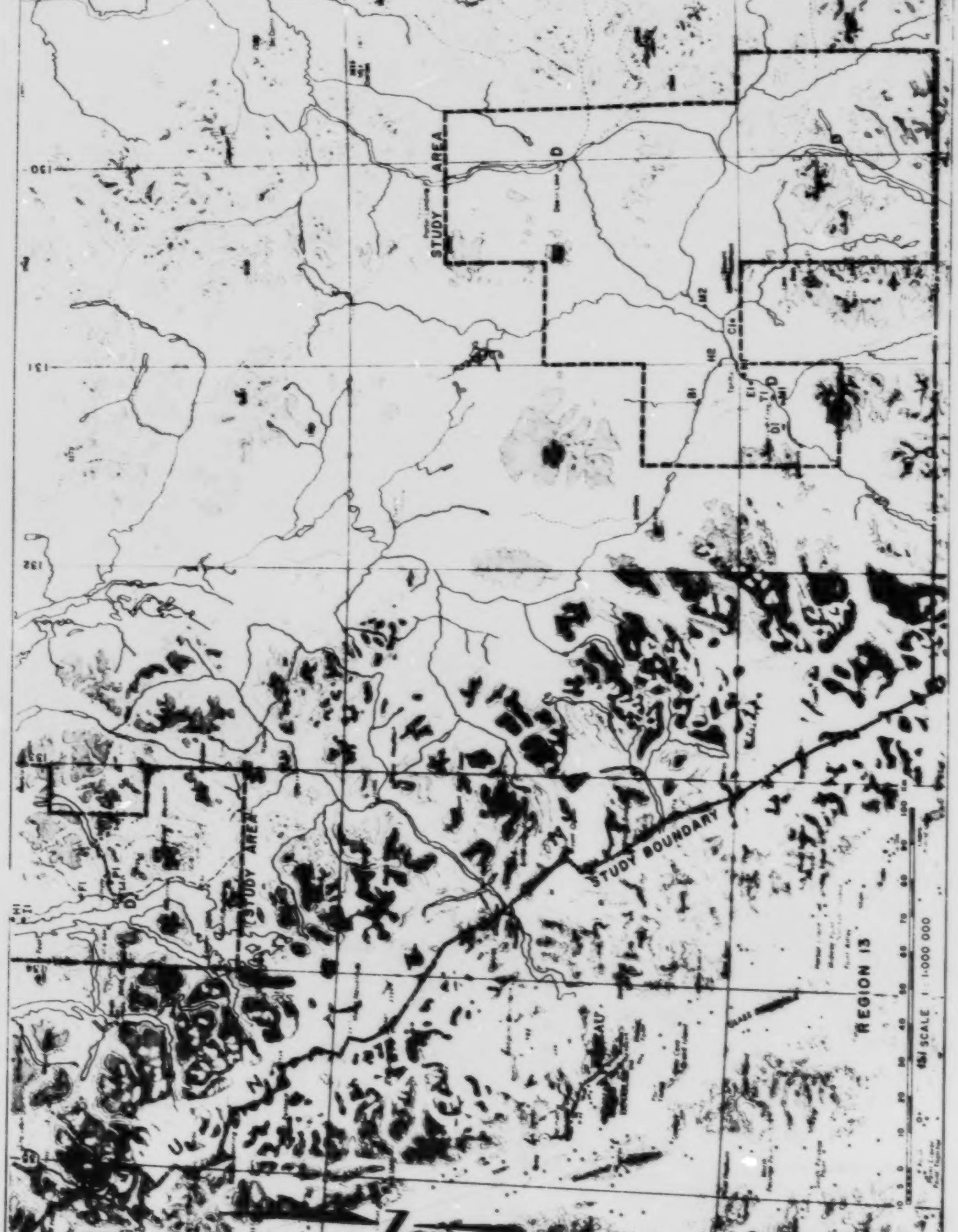

120
121
122
123
124
125
126
57
56
55
PEACE RIVER
DAWSON CREEK
Pouce Coupe
Sunset Prairie
East Pine
STUDY BOUNDARY
REGION 10


TONGASS
NATIONAL FOREST
MOUNTAINS
STUDY AREA
STUDY AREA
TRANSMISSION
LINES
STUDY BOUNDARY
BOUNDARY
REVILLAGIGEDO
ISLAND
REGION II
SCALE 1 : 1 000 000
132
131
130
129
128
127
126
57
56

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMERICAN CR<br>A1 | 56 08<br>129 54 | 81 | 5.1 | .55 | 91 | 1400<br>1.3 | 6.0 | 25<br>25 | 3340 | 8800 | 2.7 | 1.6<br>4.6 |
| BARNEY GULCH<br>B2 | 55 57<br>129 58 | 8 | .50 | .55 | 457 | 2000<br>.45 | 1.5 | 25<br>2.0 | 1590 | 3400 | 2.2 | 1.0<br>4.9 |
| BEAR R<br>B1 | 56 07<br>129 46 | 77 | 5.1 | .55 | 30 | 450<br>1.3 | 0.0 | 25<br>28 | 1100 | 4100 | 3.9 | 2.5<br>6.0 |
| BLACKSTOCK CR<br>B3 | 55 40<br>127 45 | 40 | .80 | .50 | 92 | 550<br>.56 | 2.0 | 25<br>20 | 530 | 1760 | 3.8 | 1.4<br>10 |
| CARRIGAN CR<br>C3 | 55 38<br>127 45 | 36 | .72 | .50 | 91 | 650<br>.55 | 2.0 | 25<br>16 | 470 | 1830 | 4.4 | 1.7<br>12 |
| CASCADE R<br>C1 | 56 03<br>130 02 | 68 | 4.1 | .55 | 61 | 350<br>1.0 | 0.5 | 25<br>17 | 1800 | 3100 | 1.8 | 0.9<br>3.5 |
| CAUSQUA CR<br>C4 | 55 02<br>127 16 | 52 | 1.0 | .50 | 91 | 550<br>.62 | 3.0 | 25<br>4.5 | 680 | 1920 | 3.2 | 1.2<br>8.6 |
| CLARY CR<br>C2 | 55 28<br>129 27 | 33 | 2.0 | .65 | 488 | 2050<br>.73 | 6.0 | 25<br>3.0 | 6950 | 9600 | 1.2 | 0.6<br>2.3 |
| GLACIER CR<br>G1 | 55 59<br>129 56 | 49 | 2.9 | .55 | 61 | 600<br>.99 | 2.0 | 25<br>7.0 | 1270 | 3620 | 3.0 | 1.5<br>5.9 |
| INSECT CR<br>I1 | 55 03<br>128 29 | 32 | 1.3 | .60 | 152 | 2550<br>.81 | 16 | 25<br>13 | 1430 | 8730 | 5.8 | 2.8<br>12 |
| JUNIPER CR<br>J1 | 55 07<br>127 42 | 60 | 1.2 | .60 | 91 | 1550<br>.79 | 10 | 25<br>8.0 | 780 | 4840 | 7.0 | 2.6<br>19 |
| KELSKIIST CR<br>K3 | 55 21<br>129 42 | 53 | 3.4 | .60 | 183 | 1550<br>1.0 | 2.0 | 25<br>28 | 4500 | 6900 | 1.5 | 0.8<br>2.7 |
| KSHADIN CR<br>K1 | 55 27<br>129 03 | 50 | 3.0 | .60 | 92 | 1150<br>1.1 | 18 | 69<br>6.0 | 1980 | 7600 | 3.6 | 1.9<br>7.0 |
| KWINATAHL R<br>K2 | 55 25<br>129 08 | 113 | 6.8 | .60 | 123 | 1300<br>1.4 | 15 | 69<br>1.0 | 6000 | 10400 | 1.6 | 0.9<br>3.2 |
| LUND CR<br>L1 | 55 10<br>127 20 | 27 | .54 | .50 | 153 | 1000<br>.49 | 5.0 | 25<br>16 | 590 | 2400 | 4.5 | 1.7<br>12 |

| BC SMALL HYDRO ASSESSMENT | LAT. LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN. DIA. | ACCESS ROAD | LINE kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MARMOT R<br>M1 | 55 53<br>130 00 | 94 | 5.6 | .55 | 61 | 650<br>1.3 | 0.7 | 25<br>7.0 | 2460 | 5200 | 2.2 | 1.1<br>4.3 |
| MILL CR<br>M2 | 55 06<br>128 07 | 86 | 3.4 | .60 | 61 | 1125<br>1.2 | 1.0 | 25<br>3.0 | 1490 | 5550 | 3.5 | 1.7<br>7.4 |
| SEASKINNISH CR<br>S1 | 55 16<br>128 59 | 34 | 2.4 | .60 | 136 | 1750<br>.97 | 3.0 | 25<br>2.0 | 2330 | 6850 | 2.8 | 1.5<br>5.1 |
| SEDAN CR<br>S2 | 55 05<br>128 12 | 116 | 4.6 | .60 | 61 | 850<br>1.3 | 2.0 | 25<br>8.0 | 2030 | 5230 | 2.4 | 1.2<br>5.1 |
| UNNAMED CR<br>U2 | 55 21<br>128 40 | 42 | 1.7 | .50 | 183 | 1750<br>.80 | 20 | 25<br>30 | 2200 | 8030 | 4.1 | 2.0<br>8.4 |
| UNNAMED CR<br>U3 | 55 03<br>128 07 | 65 | 2.6 | .60 | 61 | 950<br>1.0 | 5.0 | 25<br>3.3 | 1140 | 4800 | 4.0 | 1.9<br>8.4 |
| UNNAMED CR<br>U1 | 55 26<br>128 46 | 45 | .90 | .50 | 152 | 1050<br>.59 | 6.0 | 25<br>16 | 980 | 3100 | 3.6 | 1.8<br>7 |
| UTSUN CR<br>U4 | 55 27<br>127 35 | 37 | .74 | .50 | 122 | 1450<br>.61 | 2.0 | 25<br>5.0 | 650 | 2900 | 5.1 | 1.9<br>13 |
| WILSON CR<br>W1 | 55 03<br>128 17 | 27 | 1.1 | .60 | 122 | 1525<br>.71 | 2.0 | 25<br>5.0 | 950 | 3500 | 3.5 | 1.7<br>7.2 |


STUDY BOUNDARY
STUDY AREA
PEACE RIVER
REGION 12
D
Fort Nelson
Prov Park
BRITISH COLUMBIA
120
121
122
123
124
125
126
10 5 0 10 20 30 40 50 60 70 80 90 100
SCALE 1 : 1 000 000
5242


CASSIAR
CASSIAR
STUDY AREA
STUDY AREA
STUDY BOUNDARY
REGION 13
129
130
131
132
133
134
135
N
SCALE 1:1 000 000

| BC SMALL HYDRO ASSESSMENT | LAT.<br>LONG. | BASIN SIZE | DESIGN FLOW | FRAC. FIRM. | HEAD | PEN. LEN.<br>DIA. | ACCESS ROAD | LINE<br>kv/D | INST. CAP. | COST ($1000) | COST ¢/kWh | COST RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEATTY CR<br>B1 | 58 06<br>131 11 | 393 | 3.9 | .45 | 92 | 1370<br>1.2 | 19 | 25<br>17 | 2580 | 9500 | 4.7 | 2.5<br>8.6 |
| CLASSY CR<br>C1 | 58 01<br>130 47 | 84 | .84 | .45 | 152 | 900<br>.57 | 7.0 | 25<br>17 | 920 | 2950 | 4.1 | 2.2<br>7.5 |
| DODJATIN CR<br>D1 | 57 53<br>131 18 | 78 | .78 | .45 | 122 | 750<br>.55 | 3.0 | 25<br>12 | 680 | 2010 | 3.7 | 2.0<br>6.9 |
| EIGHT MILE CR<br>E1 | 57 58<br>131 05 | 27 | .27 | .45 | 91 | 150<br>.31 | 3.0 | 25<br>10 | 180 | 732 | 5.2 | 2.8<br>9.5 |
| FOURTH OF JULY CR<br>F1 | 59 40<br>133 39 | 178 | 1.8 | .30 | 92 | 1600<br>.92 | 4.0 | 25<br>8.0 | 1180 | 5760 | 9.3 | 2.7<br>32 |
| HARTZ CR<br>H2 | 58 03<br>131 00 | 33 | .33 | .45 | 213 | 1600<br>.45 | 6.0 | 25<br>9.0 | 520 | 2990 | 7.3 | 3.9<br>14 |
| HITCHCOCK CR<br>H1 | 59 55<br>133 48 | 175 | 1.8 | .30 | 62 | 1025<br>.90 | 2.0 | 25<br>40 | 780 | 4200 | 10 | 3.0<br>35 |
| INDIAN CR<br>I1 | 59 49<br>133 47 | 160 | .16 | .30 | 30 | 275<br>.78 | 2.0 | 25<br>32 | 340 | 1700 | 9.3 | 2.7<br>32 |
| MEEHAUS CR<br>M2 | 58 05<br>130 43 | 97 | .97 | .45 | 92 | 670<br>.62 | 8.0 | 25<br>20 | 640 | 2800 | 5.5 | 2.9<br>10 |
| MESS CR<br>M1 | 57 53<br>131 12 | 2350 | 24 | .45 | 61 | 1600<br>2.6 | 7.0 | 25<br>3.0 | 10300 | 25630 | 3.2 | 1.7<br>5.9 |
| NINE MILE CR<br>N1 | 57 59<br>131 02 | 20 | .20 | .45 | 213 | 950<br>.36 | 1.0 | 25<br>13 | 320 | 1300 | 5.2 | 2.8<br>9.7 |
| PINE CR DITCH<br>P1 | 59 35<br>133 35 | 450 | 4.5 | .30 | 61 | 700<br>1.2 | 2.0 | 25<br>0.5 | 1970 | 4610 | 4.4 | 2.4<br>8.1 |
| TELEGRAPH CR<br>T1 | 57 54<br>131 10 | 56 | .56 | .45 | 152 | 1200<br>.51 | 0.0 | 25<br>0.0 | 610 | 2050 | 4.2 | 2.8<br>6.3 |

# APPENDIX 2

# EXAMPLES OF SITE EVALUATION PROCEDURES

# APPENDIX 2

## CONTENTS

- SMALL HYDRO POWER EVALUATION PROCEDURE
- EXAMPLE OF SMALL HYDRO POWER SITE

FIGURE

2.1 PENSTOCK SIZING AND COMPONENT COSTING
2.2 ACCESS ROAD COSTS
2.3 GENERATING EQUIPMENT COSTS
2.4 SWITCHYARD COSTS

# SMALL HYDRO POWER EVALUATION PROCEDURE

This procedure deals with the case where a prospective power developer wants to establish whether there is a feasible small hydro power site within a reasonable distance (less than 80 kilometres) and sufficiently close to a power distribution line.

The first approach would be to refer to the Resource Map and the corresponding Table in Appendix 1, and determine if there is a suitable site already identified by this study. If there is a suitable site, the next step would be to arrange for the necessary professional services to carry out a site investigation and a pre-investment study.

Alternatively the area could be investigated to locate a site with a smaller installed capacity than covered in the inventory, or a site not documented by this office study (such as a waterfall of uncertain height, or a site with relatively small capacity). Then the procedure would be as follows:

1. Obtain the 1:50,000 (or 1: 100,000) scale topographic maps of the area and plot the sites documented in this report, for reference.

2. Study the map for potential small hydro power sites and/or make a reconnaissance in the area of interest.

   A potential site will be located on a steep part of a stream (generally 5 percent slope or more); and fed by a drainage area large enough to provide adequate flow, preferably with storage (lakes or marshes).

   The nearby power distribution line must be rated at 25 kV or less if the required installed capacity is less than 100 kW.

   Generally, select a section of creek which has the steepest possible slope but which is also far enough downstream that the water intake can catch a significant amount of the basin flow.

3. Select an intake and powerhouse site, and from the map measure the following parameters:

   - the drainage area upstream of the water intake;
   - the distance to the nearest distribution line, measured along workable terrain;
   - the access road length;
   - the gross head (the vertical drop from intake to powerhouse);
   - the penstock length and slope.

4. Evaluate the hydrology (see Appendix 5):

   Refer to Figure 5.1 and note the rainfall zone which includes the drainage basin, and compare it with the rainfall zone of the nearest gauged basin.

   Adjust the mean annual runoff ($l/sec/km^2$) of the gauged basin (Figure 5.2) by the ratio of the mean rainfall of the two basins.

   Multiply the basin area ($km^2$) by the adjusted mean annual runoff to obtain the design mean annual flow in the basin (l/sec). Convert to $m^3/s$. This result is determined from the following equation:

$$\frac{\text{(Rainfall at site)}}{\text{(Rainfall at gauged basin)}} \times \text{Mean Runoff (gauged basin)} \times \frac{\text{Basin Area}}{1{,}000} = \text{Design Flow } (m^3/s)$$

   Look up the firmness factor from Figure 5.3.

5. Determine the installed capacity by multiplying the flow times the head times a constant. The constant accounts for head losses, machine efficiency and a conversion factor:

$$\text{Flow } (m^3/s) \times \text{Gross Head } (m) \times 7.0 = \text{Installed Capacity } (kW)$$

6. Evaluate the energy potential by multiplying the installed capacity times 8760 hours/year times the Firmness Factor. The firmness factor is based on the annual flow duration curves for streams in the area and it accounts for the periods when the plant cannot generate at full capacity.

$$\text{Installed Capacity } (kW) \times 8760 \text{ (hrs/yr)} \times \text{Firmness Factor} = \text{Energy Potential } (kW.h/yr)$$

7. Determine the penstock diameter.

$$\underset{(m)}{\text{Penstock Diameter}} = .58\sqrt{\text{Design Flow } (m^3/s)}$$

This provides a conservative penstock diameter which can be optimized in final design.

8. **Determine the Total Project Cost**

Follow the procedure outlined in Figure 2.1 to determine Penstock, Intake and Powerhouse costs. Subtotal 1 is the sum of these costs.

| | | |
|---|---|---|
| Penstock Cost | See Figure 2.1 | $ |
| Intake Cost | See Figure 2.1 | |
| Powerhouse Cost | See Figure 2.1 | ________ |
| | **Subtotal 1** | **$** |

**Multiply Sub Total 1 by Site Factor:**

| | |
|---|---|
| Site near a large city | 1.0 |
| Site near a town | 1.2 |
| Site near a village | 1.3 |
| Site isolated, no road transport | 1.5 |

Generating Equipment Cost — See Figure 2.3

Assume Turbine Effective Net Head
is 90 percent of the Gross Head

Access Road Cost — See Figure 2.2 ____________

**Subtotal 2 $**

Subtotal 2 is the sum of Subtotal 1 times the Site Factor, plus Generating Equipment Cost and Access Road Cost.

Allowance for Engineering of 20% of Subtotal 2

Apply Contingency Factor of about 30% of Subtotal 2 ____________

Subtotal 3 is the sum of Subtotal 2, Engineering Allowance and Contingency Costs.

**Sub Total 3 $**

Transmission Line Cost — See Figure 3.8 ____________
**See notes added to Figure 3.8**

Total Project Cost is the sum of Subtotal 3 and the Transmission Line Cost.

TOTAL PROJECT COST $

## 9. Revenue Estimate

Choose the applicable Net Rate of Payment from the following Table (B C Hydro, April 1, 1982). Consult B C Hydro for current rates.

- For capacities OVER 35 kW - General

| | | |
|---|---|---|
| Trailing step rate | 2.197 | |
| less water tax | .314 | |
| Net to Producer | 1.883 | ¢/kW.h |

- For capacities UNDER 35 kW - General

| | | |
|---|---|---|
| Trailing step rate | 3.424 | |
| less water tax | .314 | |
| Net to Producer | 3.110 | ¢/kW.h |

- For capacities under 35 kW - RESIDENTIAL

| | | |
|---|---|---|
| Trailing step rate | 3.758 | |
| less water tax | .314 | |
| Net to Producer | 3.444 | ¢/kW.h |

Gross Revenue = Net rate of payment x Energy Potential (kW.h)

Net Revenue = Gross Revenue less the following:

1. Revenue lost to Maintenance and Repair (allow 10% for the times plant is shut down).
2. Routine Maintenance and Operation (about 1.0% of capital cost but some installations could have costs as high as 2 - 4% with full time attendance at a small site).

Convert the Net Revenue to a percentage of Capital Cost and evaluate the project economics.

**Example of Small Hydro Power Site**

As an example of the procedure the following site has been analysed:

| | | |
|---|---|---|
| Creek Name: | Zeballos (Little) River | |
| Location: | Latitude 49° 59'<br>Longitude 126° 45' | |
| Powerhouse Elevation: | 304 m | |
| Intake Elevation: | 514 m | |
| Gross Head: Intake Elevation - Powerhouse Elevation: | 210 m | |
| Horizontal Penstock Length: | 750 m | |
| Basin Area: | 9 $km^2$ | |
| Access Road: | 0.4 km | |
| Distance to nearest transmission line | 6 km | |
| Rating of transmission line: | 25 kV | |
| Rainfall in Zeballos (Little) River Basin: | 150 inches/year | **Figure 5.1** |
| Rainfall in adjacent gauged basin: | 150 inches/year | **Figure 5.1** |
| Runoff in adjacent gauged basin | 168 litres/sec/$km^2$ | **Figure 5.2** |

**Calculated Mean Annual Flow:**

$$\frac{150 \text{ inches/year}}{150 \text{ inches/year}} \times 168 \text{ litres/sec/km}^2 \times \frac{9 \text{ km}^2}{1000} = 1.5 \text{ m}^3\text{/sec}$$

Firmness Factor (Figure 5.3) 65% or 0.65

**Installed Capacity:**

$$1.5 \text{ m}^3\text{/sec} \times 210 \text{ m} \times 7.0 = 2200 \text{ kW}$$

**Energy Potential:**

$$(2200 \text{ kW})\ (8760 \text{ hrs})\ (0.65) = 12{,}530{,}000 \text{ kW.h}$$

**Penstock Radius:**

$$0.29\sqrt{1.5} = 0.36 \text{ m}$$

In the example for the Little Zeballos River, the calculations are as follows:

a) **Penstock Cost - (Empirical Method)**

1. Vertical Drop H = 210 m

   Horizontal Length l = 750 m

   Actual Penstock Length $L = \sqrt{H^2 + l^2}$

   $L = \sqrt{(210)^2 + (750)^2}$ = 780 m

   Design Flow Q = 1.5 $m^3/s$

2. HMIN = $90/\sqrt{Q}$ (Vertical distance below intake at which penstock goes beyond minimum thickness)

   HMIN = $90/\sqrt{1.5}$ = 73.5 m

   HMIN IS LESS THAN H

3. CALCULATE t (See simplified method following page)

   (i) Calculate T (Maximum thickness)

   $$T = 4.7 \times 10^{-5} \times H \times \sqrt{Q}$$

   $$T = 4.7 \times 10^{-5} \times 210 \times \sqrt{1.5} = 0.0121 \text{ m}$$

   (ii) Calculate t (Average thickness)

   $$t = \frac{HMIN}{H} \times 0.0064 + \left(\frac{H - HMIN}{H}\right)\left(\frac{T + 0.0064}{2}\right)$$

   $$t = \frac{73.5}{210} \times 0.0064 + \left(\frac{210 - 73.5}{210}\right)\left(\frac{0.0064 + 0.0121}{2}\right) = 0.0082 \text{ m}$$

4. CALCULATE THE WEIGHT OF THE PENSTOCK

   $W = t\,(2\pi R)\,(7860)L$

   $W = 0.0082\,(\pi)\,(0.71)\,(7860)\,(780) = 112{,}000$ kg

## SIMPLIFIED METHOD FOR CALCULATING PENSTOCK WEIGHT

1. Let $H$ = Vertical drop of penstock

   $L$ = Actual Length of Penstock

   $Q$ = Design Flow

2. HMIN $= 90/\sqrt{Q}$ m **Assuming F S = 1.5 (Factor of Safety)**
   **tMIN = 0.00635**

3. If HMIN larger than H, then t = 0.0064 m

   If HMIN smaller than H:

   1. CALCULATE T

   $$T_{(m)} = 4.7 \times 10^{-5} \times H \times \sqrt{Q}$$

   2. CALCULATE t

   $$t_{(m)} = \frac{HMIN}{H} \times 0.0064 + \left(\frac{H - HMIN}{H}\right)\left(\frac{T + 0.0064}{2}\right)$$

4. CALCULATE WEIGHT W

$$W_{(kg)} = t \times 2\pi R \times 7860 \times L$$

**Approximate Cost of penstock**

$= (112{,}000) \times (\text{slope factor}) \times (\text{installation factor}) \times {}^{\$1}/\text{Kg}$

**where** slope factor = 1.13 **(See Fig 2.1)**

Installation factor = 4.7 **(See Fig 2.1)**

Approximate Penstock Cost = 112,000 kg x(1.13) (4.7) (\$1/kg) = \$595,000

b) **Intake Cost** **(Empirical Method)**

Intake cost = **\$20,000** + 50,000 (Design Flow in $m^3$)

Intake cost = **\$20,000** + 50,000 (1.5) = **\$100,000** (See Fig 2.1)
**(\$20,000 is an assumed fixed cost)**

c) **Powerhouse Cost** **(Empirical Method)** **(See Fig 2.1)**

First select an appropriate turbine from Figure 3.2

1. $P(hp) = Q\,(cfs) \times h(ft) \times 0.1 = (1.5\ m^3/sec)\left(\dfrac{35.3\ ft^3/sec}{m^3/sec}\right)(210\ m)\left(\dfrac{3.28ft}{m}\right)(0.1) = 3650\ hp$

   **(Definitions are shown on Figure 3.2)**

2. Try N = 1200 rpm **(most efficient operating speed)**

$$Ns = \frac{1200\sqrt{3650}}{((210)(3.28))^{1.25}} = 20.5 \text{ (specific speed)}$$

3. From Chart A, this means that a Francis turbine will be selected.

With a gross head of 210 m (689 feet) and zero draft head, Chart B recommends that the specific speed Ns be no greater than about 30

**Therefore:** A Francis turbine with a speed of 1200 rpm is OK
**Note that this range is also suitable for a Turgo Impulse Wheel**
**(see Table 2.1)**

4. $Z_1 = 33.1 - (\sigma_c \times H) =$ Maximum Turbine Elevation above tailwater
(to prevent cavitation in Francis or Propeller turbines.
See Section 2.3 and Fig 3.2).

**Where $\sigma_c$ is about .025 from Chart C (Figure 3.2)**
$z_1 = 15.8$ feet - Therefore OK

5. Turbine runner diameter

$$D\,(Ft) = \frac{153.3 \quad 689}{1200}(0.75) = 2.5 \text{ ft} = .75 \text{ m}$$

**Power house dimensions are as follows:**

Length of Powerhouse = 3.6 m + 11 (.75 m) = 11.9 m

Width of Powerhouse = 2.1 m + 6.5 (.75 m) + 4 (.8 m) = 10.2 m

| | | | |
|---|---|---|---|
| | **Powerhouse Cost** = (\$2400/$\text{m}^2$) (10.2 m) (11.9 m) | | **$ 291,000** |
| | **SUB TOTAL 1** | | **1,000,000** |
| | **Site Factor (1.4) x Sub Total 1** | | **$ 1,400,000** |
| d) | **Generating Equipment Cost** | (See Fig 2.3) | |
| | Generating Equipment Cost | | $ 500,000 |
| e) | **Access Road Cost** | (See Fig 2.2) | |
| | Access Road Cost = ($84,000/km) (0.4 km) | | $ 34,000 |
| | SUB TOTAL 2 | | $ 1,934,000 |
| | Allowance for Engineering 20% | | 387,000 |
| | Apply a Contingency Factor of about 30% | | $ 580,000 |
| | SUB TOTAL 3 | | $ 2,900,000 |
| f) | **Transmission Line Cost** | (See Fig 3.8) | |
| | 25 kV line will be required | | |
| | **Therefore:** | | |
| | Transmission Line Cost = $(6\ \text{km})\ \frac{(\$50{,}000)}{\text{km}}$ | | $ 300,000 |
| | TOTAL PROJECT COST | | $ 3,200,000 |

**Revenue Estimate**

| | |
|---|---|
| Net Water Revenue/year = (12,530,000) x (0.01883) | = $ 236,000 |
| Percentage of Capital Cost | 7.38% |
| Interest Rate: Assume | 13% |
| Assumed Energy Inflation Rate | 8% |

**Recommendation for Further Work:**

Conduct economic study
Apply for land rights
Perform preliminary engineering
Apply for water rights
Negotiate with B C Hydro
Final design
Order turbine
Issue construction contract
Commission plant

## STANDARD STEEL SIZES

| DIAMETER |  |  | WALL THICKNESS |  |  |  |
|---|---|---|---|---|---|---|
|  |  |  | min. |  | max. |  |
| IN |  | m | IN. | mm | IN. | mm |
| 6 | (ID) | 0.152 | 0.125 | 3.2 | 0.432 | 11.0 |
| 8 | ↓ | 0.203 | 0.156 | 4.0 | 0.500 | 12.7 |
| 10 | ↓ | 0.254 | 0.203 | 5.2 | ↓ | ↓ |
| 12 | ↓ | 0.308 | 0.203 | 5.2 | ↓ | ↓ |
| 16 | ↓ | 0.406 | 0.219 | 5.6 | ↓ | ↓ |
| 18 | (OD) | 0.457 | 0.250 | 6.4 | ↓ | ↓ |
| ↓ | ↓ |  | ↓ | ↓ | ↓ | ↓ |
| 30 | ↓ | 0.762 | 0.250 | 6.4 | 0.500 | 12.7 |
| 36 | ↓ | 0.914 | 0.312 | 7.9 | 0.562 | 14.3 |
| ↓ | ↓ |  | ↓ | ↓ | ↓ | ↓ |
| 80 | ↓ | 2.03 | 0.312 | 7.9 | 0.562 | 14.3 |

NOTE: ID = INTERIOR DIAMETER
OD = EXTERIOR DIAMETER
MINIMUM ALLOWABLE THICKNESS = .00624m

CHART A

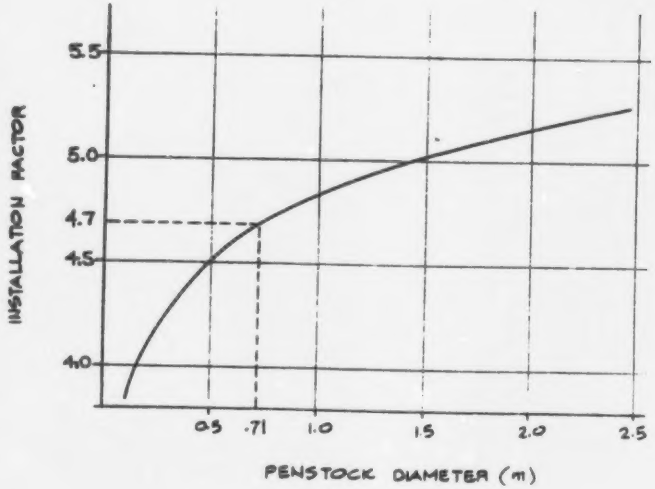


CHART B

## SLOPE FACTOR

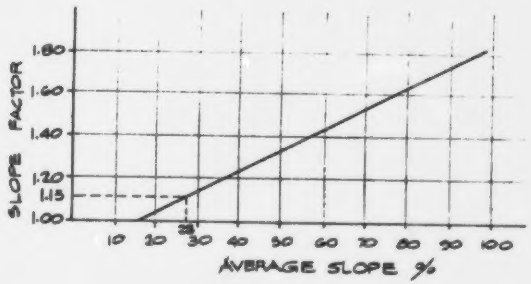


CHART C

## POWERHOUSE AREA

1. CALCULATE RUNNER DIAMETER D FROM FIGURE 3.2 CONVERT TO METRES.
2. FOR A PELTON WHEEL

   $L(m) = 3.6m + 7 \times D(m)$

   $W(m) = 2.1m + 3.5 \times D + 4 \times 2R \ (m)$

   $AREA \ (m^2) = L \times W$
3. FOR A FRANCIS TURBINE (HORIZONTAL)

   $L(m) = 3.6m + 11 \times D$

   $W(m) = 2.1m + 6.5 D + 4 \times 2R \ (m)$

   $AREA \ (m^2) = L \times W$
4. PROPELLER TURBINE

   THE POWERHOUSE SIZE DEPENDS ON WHETHER THE TURBINE IS HORIZONTAL OR VERTICAL, AS WELL AS ON SITE CONDITIONS. CONSULT A MANUFACTURER TO DETERMINE THE OUTSIDE DIMENSIONS OF THE TURBINE/GENERATOR ASSEMBLY, AND ADD ABOUT 3.0m TO EACH DIMENSION TO APPROXIMATE THE BUILDING SIZE.

CHART D

## COST EVALUATION PROCEDURE

(BASED ON STEEL PENSTOCKS)

1. CALCULATE PENSTOCK RADIUS R

   $R(m) = 0.29 \sqrt{FLOW \ (m^3/s)}$

   PENSTOCK DIAMETER = 2 x R
   DIVIDE PIPE INTO PRESSURE ZONES FOR ECONOMY
2. CALCULATE MAXIMUM THICKNESS T (m)

   $T = 4.7 \times 10^{-6} \times GROSS \ HEAD \ (m) \times \sqrt{FLOW \ (m^3/s)}$

   CHOOSE A STANDARD THICKNESS FROM CHART A.
3. CALCULATE THE WEIGHT OF PIPE

   $W = T \times 2\pi R \times 7860 \ kg/m^3 \times LENGTH \ (m)$

   (FOR EACH PRESSURE ZONE)
4. DETERMINE INSTALLATION FACTOR (I.F.) (CHART B)
5. DETERMINE SLOPE FACTOR (S.F.) (CHART C)
6. $PENSTOCK \ COST = W \times \frac{\$1.0}{kg} \times I.F. \times S.F.$
7. INTAKE COST = \$20,000 + 50,000 x FLOW ($m^3/s$)
8. SELECT AN APPROPRIATE TURBINE USING FIG. 3.2
9. POWERHOUSE COST = \$2400 x AREA ($m^2$)
   DETERMINE AREA FROM CHART D

**PENSTOCK SIZING AND COMPONENT COSTING**

FIGURE 2.1

DCS 5242

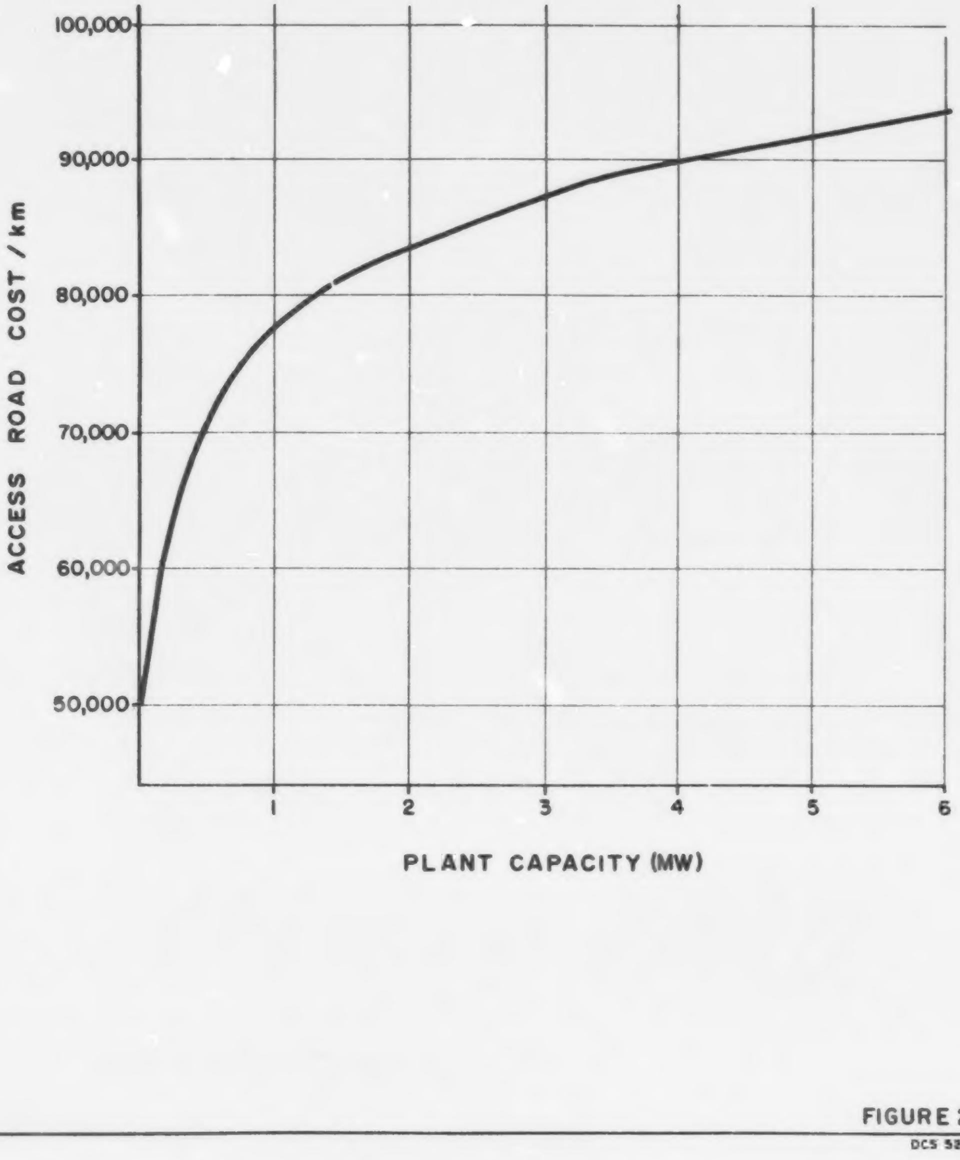
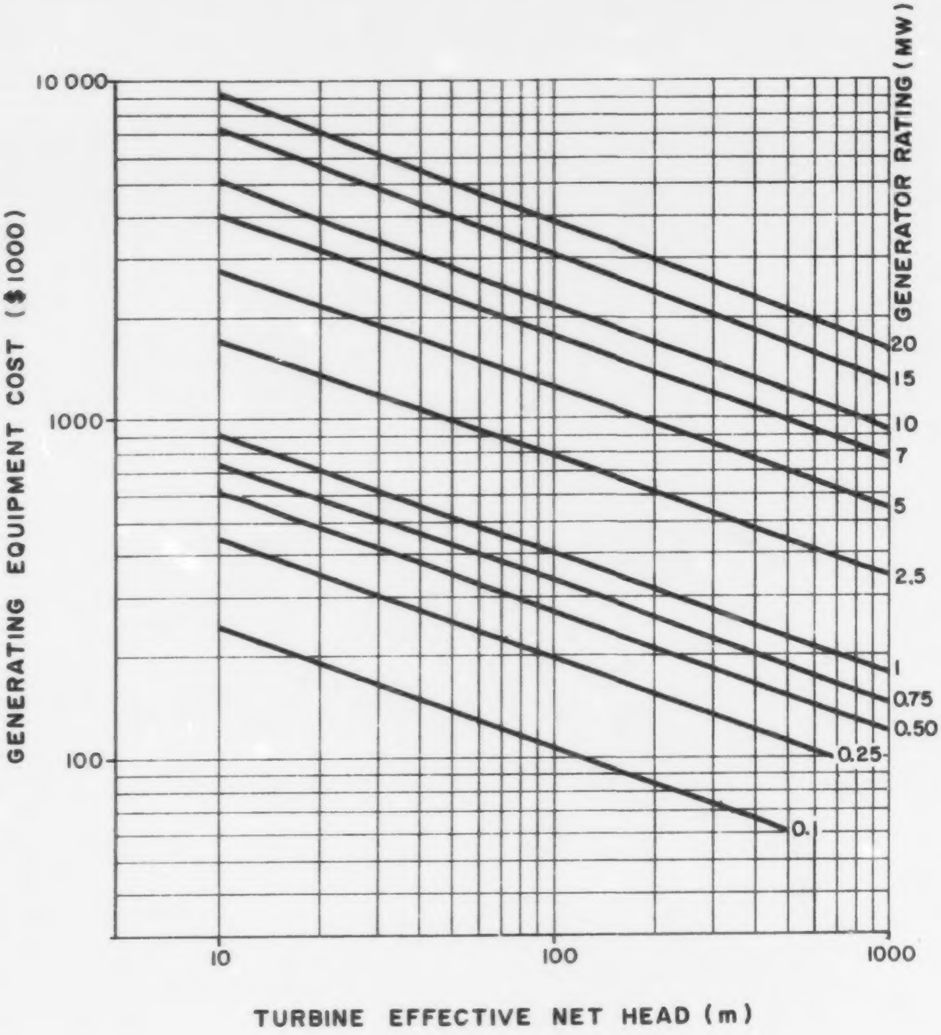


FIGURE 2·2

DCS 5242



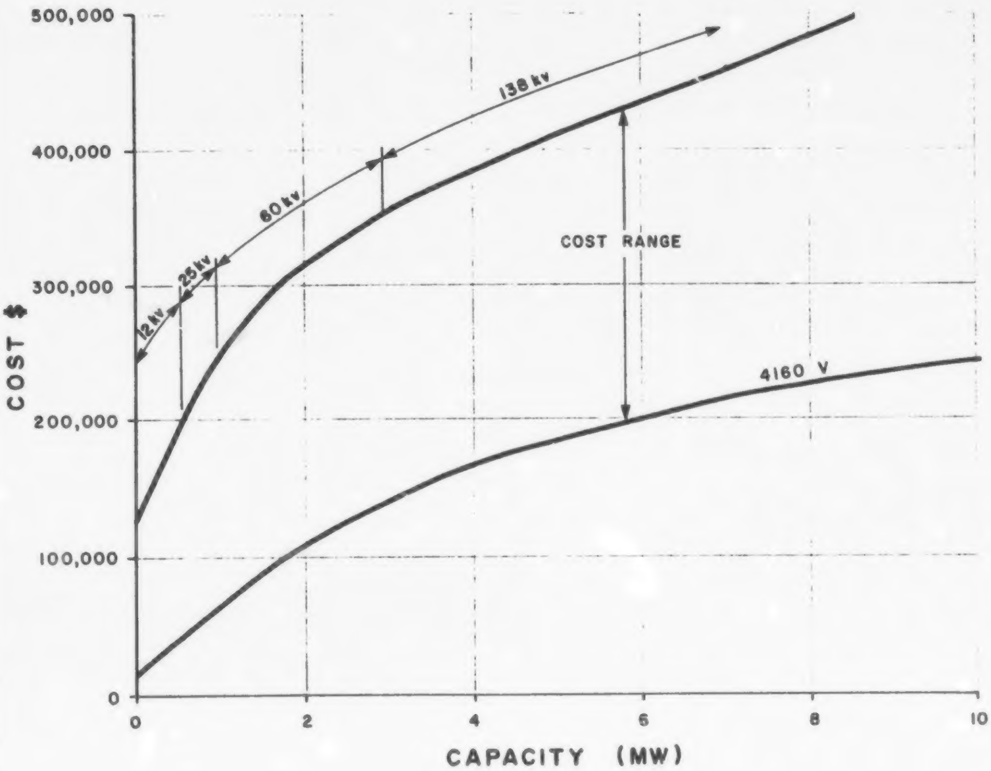
NOTES:

1. Cost base March 1982
2. Costs can vary ± 30% depending on the turbine type and prevailing market conditions.

**GENERATING EQUIPMENT COSTS**

FIGURE 2·3

5242 DCS



1. Upper cost limit is for a low voltage generator and a line voltage as shown.
2. Lower cost limit is for a generator and line voltage the same.
3. Costs include switchyard (transformers, circuit breaker, disconnect switch, potential transformers, lightning arrestors), civilworks, and utility interconnection charge.
4. Based on Tudor Engineering, 1978.

SWITCHYARD COSTS

FIGURE 2-4

DCS

# APPENDIX 3

## MANUFACTURERS INFORMATION
## SPECIFICATIONS AND SYSTEM DIAGRAMS

# APPENDIX 3

## CONTENTS

FIGURE

3.1 SMALL HYDRO POWER SYSTEM DIAGRAM

3.2 TURBINE APPLICATION CHART

3.3 GOVERNOR SYSTEMS

3.4 TYPICAL PROTECTION SYSTEM

3.5.1 PENSTOCK COST DATA

3.5.2 PENSTOCK APPLICATION CHART

3.6 INTAKE DETAILS

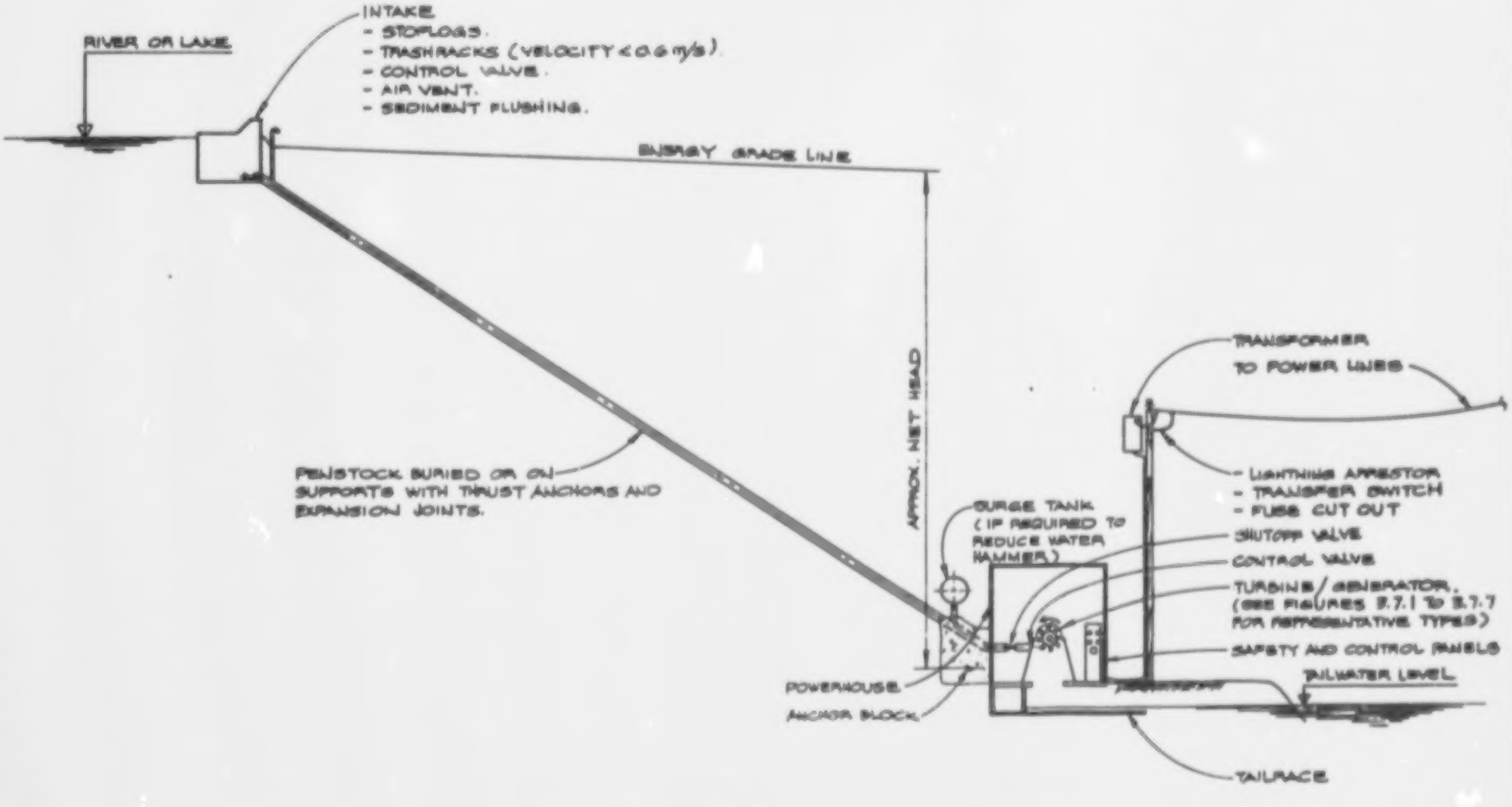
3.7.1 POWERHOUSE LAYOUT 1
3.7.2 2
3.7.3 3
3.7.4 4
3.7.5 5
3.7.6 6
3.7.7 7

3.8 TRANSMISSION LINE SIZING

LIST OF EQUIPMENT SUPPLIERS

TURBINE DATA SHEET

GENERATOR DATA SHEET


RIVER OR LAKE
INTAKE
- STOPLOGS.
- TRASHRACKS (VELOCITY < 0.6 m/s).
- CONTROL VALVE.
- AIR VENT.
- SEDIMENT FLUSHING.
ENERGY GRADE LINE
APPROX. NET HEAD
PENSTOCK BURIED OR ON SUPPORTS WITH THRUST ANCHORS AND EXPANSION JOINTS.
SURGE TANK (IF REQUIRED TO REDUCE WATER HAMMER)
POWERHOUSE
ANCHOR BLOCK
TRANSFORMER
TO POWER LINES
- LIGHTNING ARRESTOR
- TRANSFER SWITCH
- FUSE CUT OUT
SHUTOFF VALVE
CONTROL VALVE
TURBINE/GENERATOR. (SEE FIGURES 3.7.1 TO 3.7.7 FOR REPRESENTATIVE TYPES)
SAFETY AND CONTROL PANELS
TAILWATER LEVEL
TAILRACE

SMALL HYDRO POWER SYSTEM DIAGRAM

FIGURE 3-1

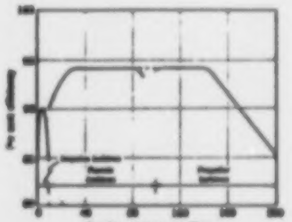

Maximum turbine efficiency as a function of specific speed. (Moody)

CHART A

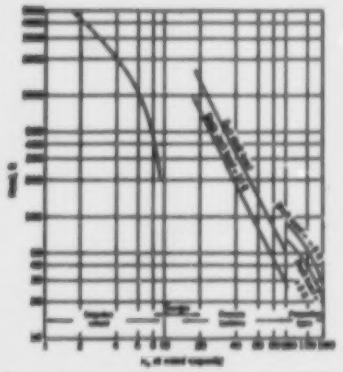
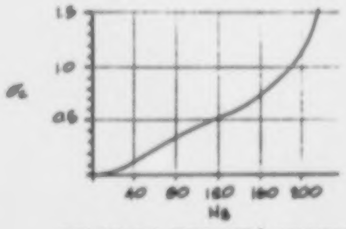

Recommended limits of specific speed for turbines under various effective heads at sea level with water temperature at 80° F. (After Moody)

CHART B



RELATION BETWEEN CAVITATION PARAMETER $\sigma_c$ AND TURBINE SPECIFIC SPEEDS $N_S$

CHART C

$$D_{(ft)} = \frac{153.3\sqrt{H_{(ft)}}\ \phi}{N_{(RPM)}}$$

$\phi \approx .43 - .48$ (IMPULSE)

$\phi \approx 0.6 - 0.9$ (FRANCIS)

$\phi \approx 1.4 - 2.0$ (PROPELLER)

DETERMINING RUNNER DIAMETER "D"

CHART D

DEFINITIONS

$N_S$ = SPECIFIC SPEED = A NUMBER WHICH CLASSIFIES TURBINES AS TO TYPE. TWO TURBINES OF IDENTICAL GEOMETRICAL SHAPE BUT DIFFERENT SIZE WILL HAVE THE SAME SPECIFIC SPEED

$N_{RPM}$ = MOST EFFICIENT OPERATING SPEED IN REVOLUTION /MIN.

TAILWATER = ELEVATION OF CHANNEL JUST DOWNSTREAM OF TURBINE

INSTRUCTIONS FOR TURBINE SELECTION

1. DETERMINE POWER AVAILABLE

$$P_{(HP)} = Q_{(cfs)} \times H_{(ft)} \times .1 \text{ (CONVERSION FACTOR)}$$

2. DETERMINE SPECIFIC SPEED

$$N_S = \frac{N_{RPM}\sqrt{P_{(HP)}}}{(H_{(ft)})^{5/4}}$$

CHOOSE $N_{RPM}$ TO BE THE FASTEST SYNCHRONOUS SPEED POSSIBLE

$$N_{RPM} = \frac{7200}{i}, \text{ WHERE } i \text{ IS AN EVEN NUMBER}$$

3. SELECT A TURBINE TYPE FROM CHART A AND CHART B

4. IF THE TURBINE SELECTED IS A FRANCIS OR PROPELLER, CHECK THE CAVITATION INDEX AND TAILWATER LEVEL TO ENSURE THAT THE TURBINE IS NOT SET TOO HIGH

$$\underbrace{Z_1}_{\text{HEL. ABOVE TAILWATER}} = \underbrace{(33.1 \text{ ft})}_{\text{VACUUM LIFT OF WATER AT SEA LEVEL } 70^\circ F} - \sigma_c H \text{ (ft)}$$

$\sigma_c$ FROM CHART

IF THE TAILWATER SETTING IS UNWORKABLE, SELECT A SLOWER SPEED & REPEAT STEP C.

5. DETERMINE RUNNER DIAMETER (CHART D)

6. CONFIRM THE SELECTION WITH A MANUFACTURER.

CONVERSIONS

DESIGN FLOW = Q IN cfs OR $m^3/s$

35.3 cfs = 1 $m^3/s$

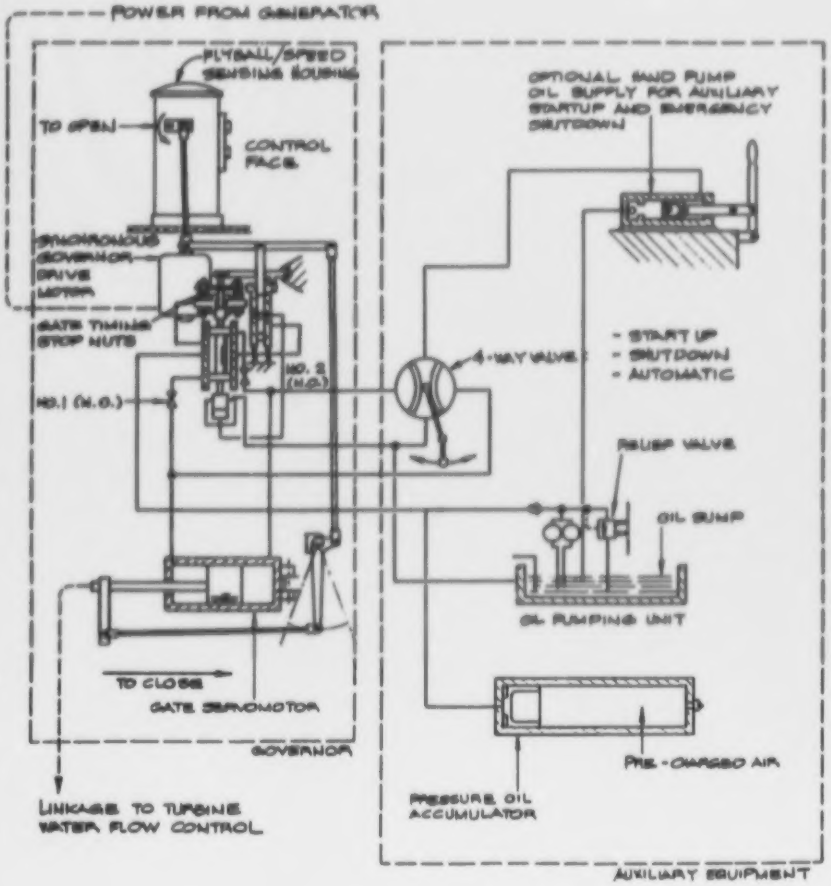
HEAD ON TURBINE = H IN ft. OR m

3.28 ft. = 1m

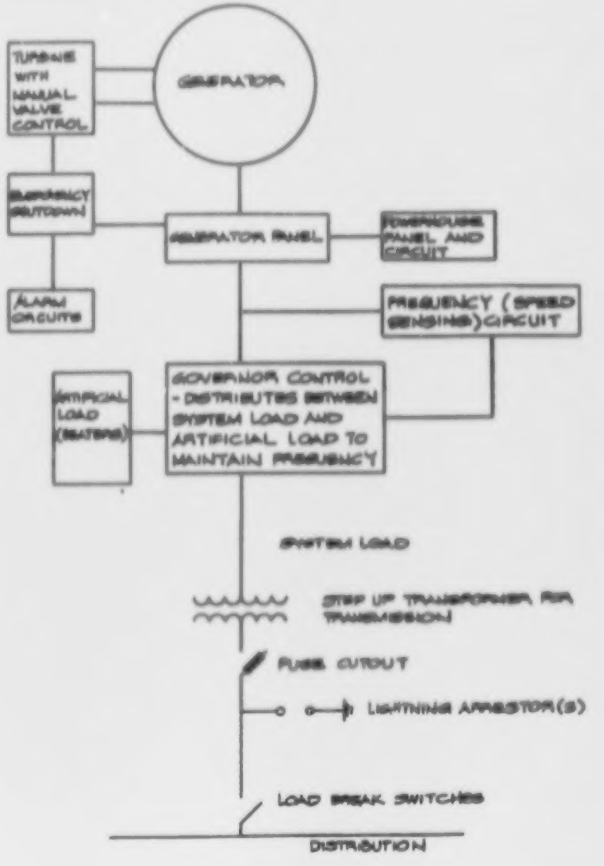
H IS ACTUALLY THE NET EFFECTIVE HEAD ON THE TURBINE BUT SUFFICIENT ACCURACY CAN BE OBTAINED AT THIS LEVEL BY TAKING THE DIFFERENCE BETWEEN THE INTAKE AND POWERHOUSE ELEVATIONS.

TURBINE APPLICATION CHART

FIGURE 3.2


POWER FROM GENERATOR
FLYBALL/SPEED SENSING HOUSING
TO OPEN
CONTROL FACE
SYNCHRONOUS GOVERNOR DRIVE MOTOR
GATE TIMING STOP NUTS
NO. 2 (N.O.)
NO. 1 (N.C.)
TO CLOSE
GATE SERVOMOTOR
GOVERNOR
LINKAGE TO TURBINE WATER FLOW CONTROL
OPTIONAL HAND PUMP OIL SUPPLY FOR AUXILIARY STARTUP AND EMERGENCY SHUTDOWN
4-WAY VALVE
- START UP
- SHUTDOWN
- AUTOMATIC
RELIEF VALVE
OIL SUMP
OIL PUMPING UNIT
PRE-CHARGED AIR
PRESSURE OIL ACCUMULATOR
AUXILIARY EQUIPMENT

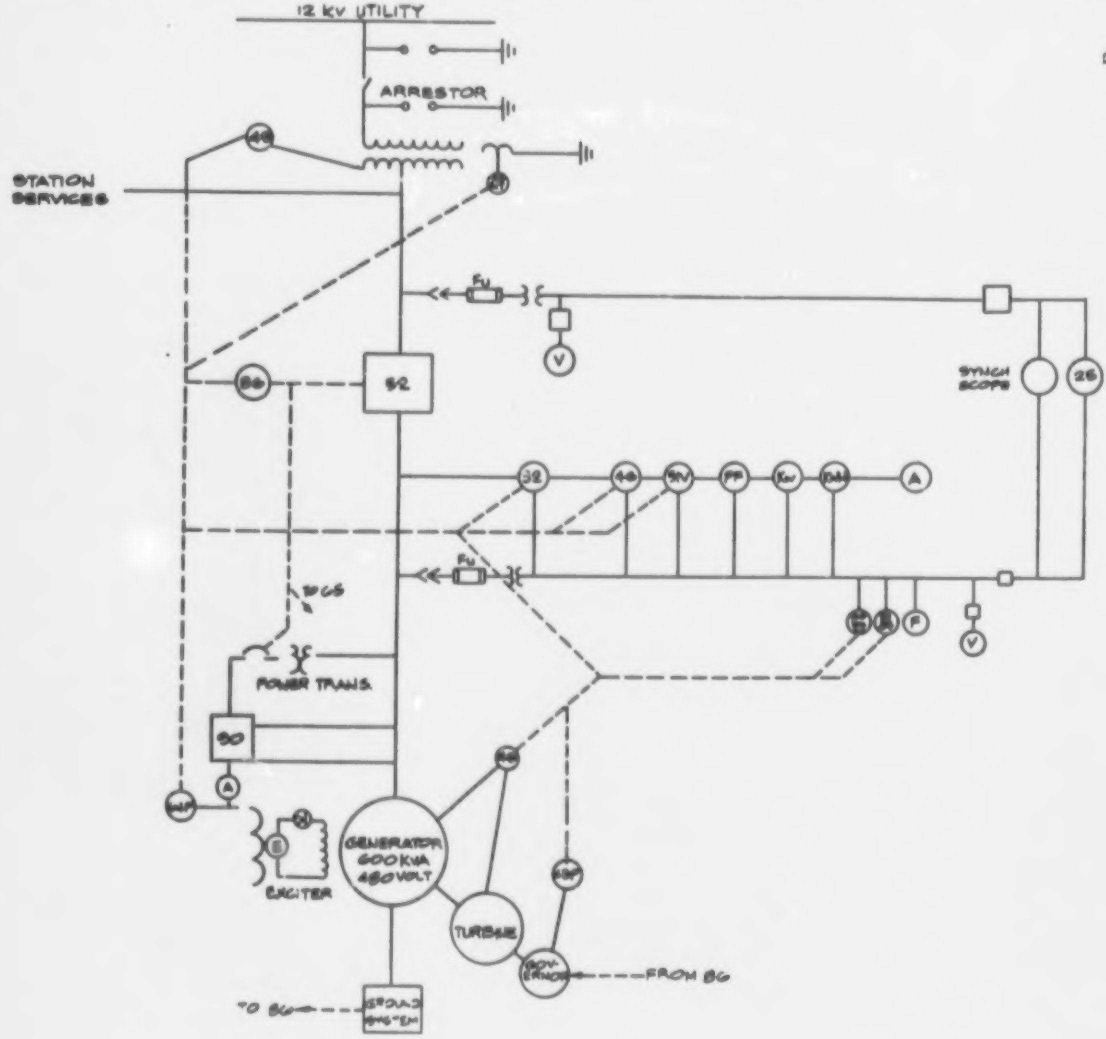
WOODWARD HYDRAULIC GATESHAFT GOVERNOR


TURBINE WITH MANUAL VALVE CONTROL
GENERATOR
EMERGENCY SHUTDOWN
GENERATOR PANEL
POWERHOUSE PANEL AND CIRCUIT
ALARM CIRCUITS
FREQUENCY (SPEED SENSING) CIRCUIT
ARTIFICIAL LOAD (HEATERS)
GOVERNOR CONTROL - DISTRIBUTES BETWEEN SYSTEM LOAD AND ARTIFICIAL LOAD TO MAINTAIN FREQUENCY
SYSTEM LOAD
STEP UP TRANSFORMER FOR TRANSMISSION
FUSE CUTOUT
LIGHTNING ARRESTOR(S)
LOAD BREAK SWITCHES
DISTRIBUTION

LOAD DUMPING GOVERNOR SCHEMATIC

**GOVERNOR SYSTEMS**

FIGURE 3-3


12 KV UTILITY
ARRESTOR
STATION SERVICES
46
Fu
V
86
52
32
46
51V
PF
Kw
KWH
A
SYNCH SCOPE
25
Fu
F
V
POWER TRANS.
90
A
E
EXCITER
GENERATOR 600KVA 480VOLT
TURBINE
GOV-ERNOR
FROM 86
TO 86
GROUND SYSTEM

**DEVICE LIST**

| DEVICE STANDARD CODE NO. | DESCRIPTION |
|---|---|
| 25 | SYNCH CHECK |
| 32 | REVERSE POWER |
| 46 | PHASE BALANCE, NEG. SEQ. OVERCURRENT |
| 49 | TEMPERATURE (WINDINGS, BEARINGS) |
| 50/51T | TRANSFORMER GROUND OVER CURRENT |
| 51V | VOLTAGE RESTRAINED TIME OVERCURRENT |
| 52 | MAIN BREAKER, AIR OR VACUUM |
| 59/27 | OVER / UNDER VOLTAGE |
| 63P | LOW OIL PRESSURE |
| 64F | EXCITER FIELD GROUND |
| 81OV | OVER / UNDER FREQUENCY |
| 86 | LOCKOUT RELAY |
| 90 | VOLTAGE REGULATOR WITH PARALLEL COMPENSATION |

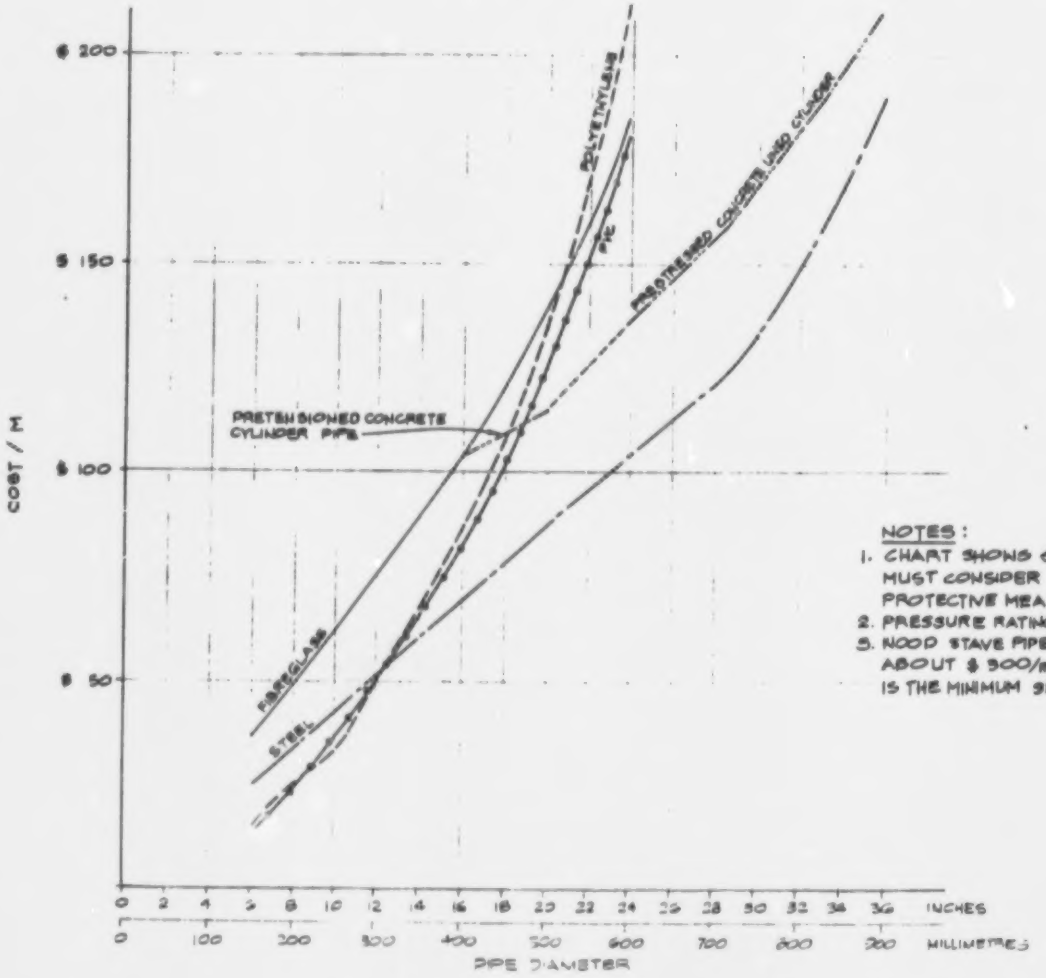
**METERS**

| | |
|---|---|
| A | AMPERES |
| F | FREQUENCY |
| PF | POWER FACTOR |
| V | VOLTS |
| Kw | KILOWATTS |
| KWH | KILOWATTHOUR |

NOTE: THIS EXAMPLE IS BASED ON AN ACTUAL PROJECT. DIFFERENCES WILL OCCUR FOR DIFFERENT UTILITIES, GENERATOR OUTPUTS, LINE VOLTAGES AND LINE CLASSIFICATIONS.

TYPICAL PROTECTION SYSTEM

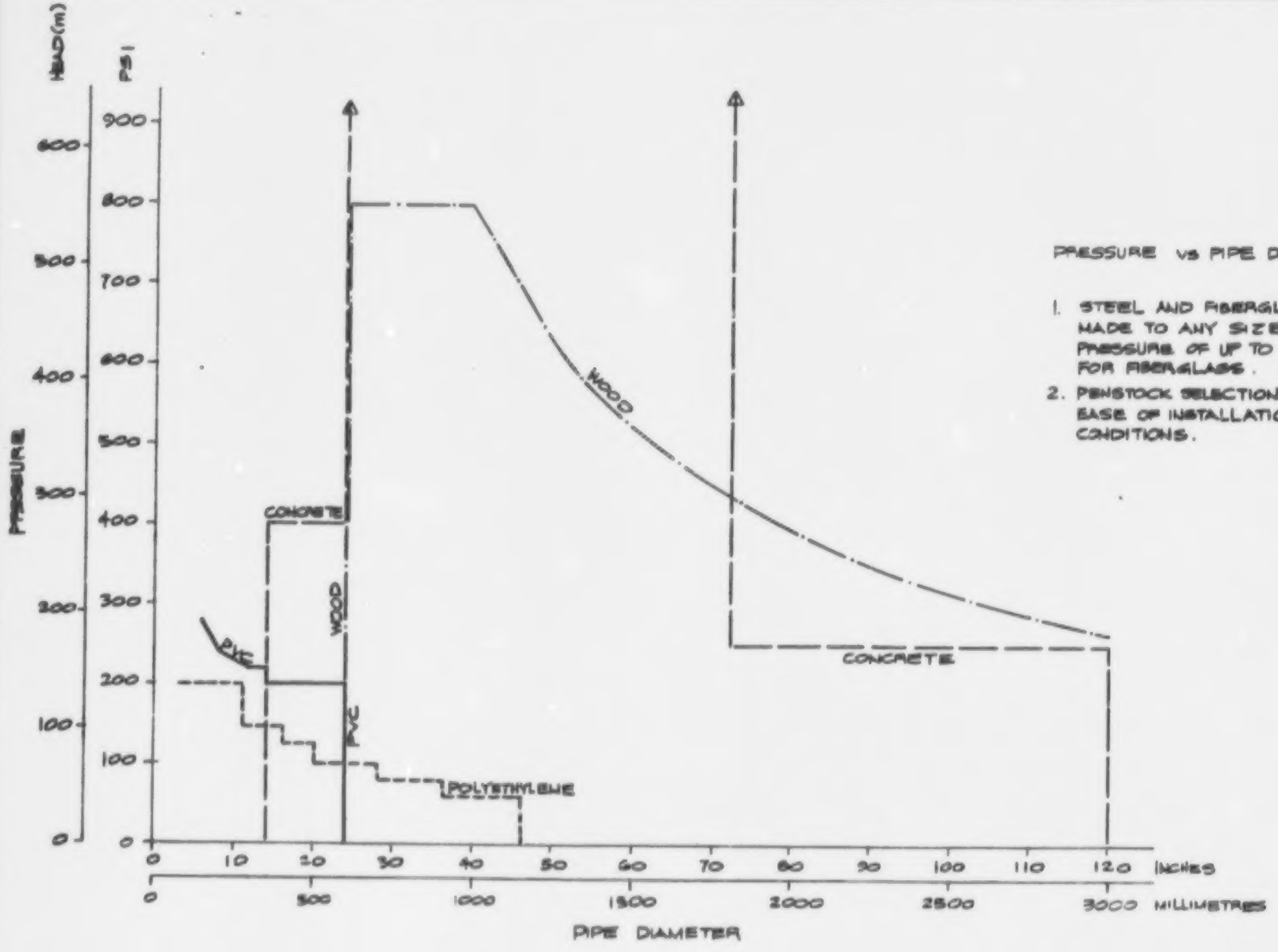
FIGURE 3.4



NOTES:

1. CHART SHOWS SUPPLY COST ONLY. INSTALLED COSTS MUST CONSIDER TERRAIN, EASE OF INSTALLATION, AND PROTECTIVE MEASURES.
2. PRESSURE RATING SHOWN IS 100 psi (700 Kpa)
3. WOOD STAVE PIPE NOT SHOWN. COST WOULD BE ABOUT $ 300/m FOR 600 mm Φ PIPE, WHICH IS THE MINIMUM SIZE MADE.

PENSTOCK COST DATA
FIGURE 3.5.1

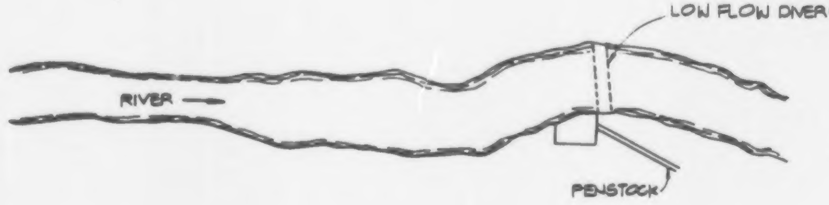


PRESSURE vs PIPE DIAMETER

1. STEEL AND FIBERGLASS PIPE CAN BE CUSTOM MADE TO ANY SIZE UP TO 6mϕ AND A PRESSURE OF UP TO 1050 KPa (150 psi) FOR FIBERGLASS.
2. PENSTOCK SELECTION MUST ALSO EVALUATE THE EASE OF INSTALLATION, DURABILITY AND TERRAIN CONDITIONS.

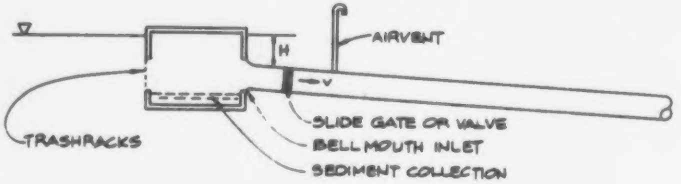
**PENSTOCK APPLICATION CHART**

FIGURE 3-5-2


LOW FLOW DIVERSION
RIVER →
PENSTOCK

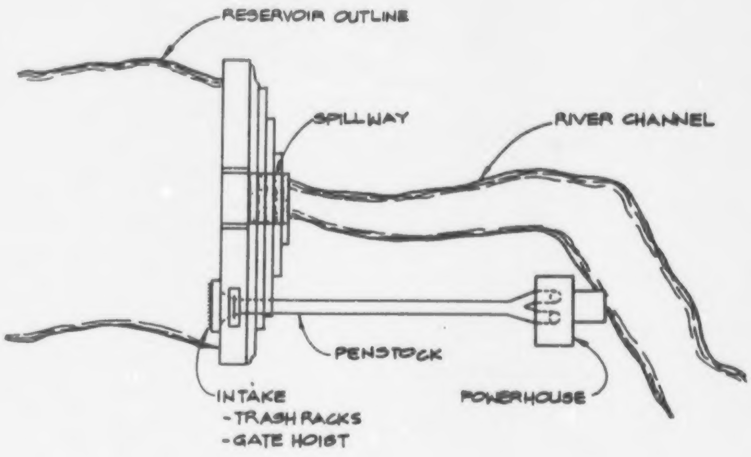
PLAN (SMALL RUN OF RIVER PLANT)
N.T.S

INTAKE SHOULD BE LOCATED IN :
- DEEP WATER TO AVOID FREEZING AND VORTICITY
- CALM WATER TO AVOID FRAZIL ICE
- AREAS WHERE THERE IS MINIMAL SEDIMENT DEPOSITION
- AREAS THAT ARE STABLE IN FLOODS


∇
H
AIRVENT
→V
TRASHRACKS
SLIDE GATE OR VALVE
BELLMOUTH INLET
SEDIMENT COLLECTION

- ENSURE THAT VELOCITY THROUGH TRASH RACK IS LESS THAN 0.6 m/s
- ENSURE THAT $\Sigma$ (HEADLOSSES + $\frac{V^2}{2g}$) ARE LESS THAN H

PROFILE
N.T.S.

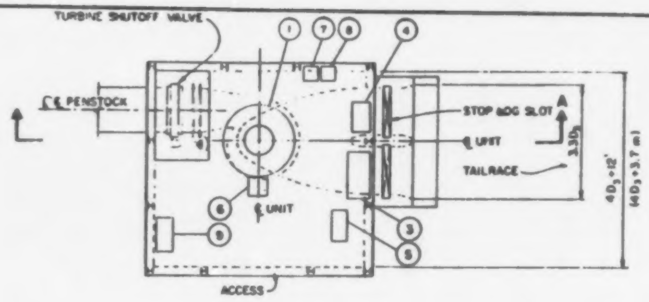

RESERVOIR OUTLINE
SPILLWAY
RIVER CHANNEL
PENSTOCK
POWERHOUSE
INTAKE
-TRASH RACKS
-GATE HOIST

PLAN (LARGE PLANT WITH STORAGE)
N.T.S.

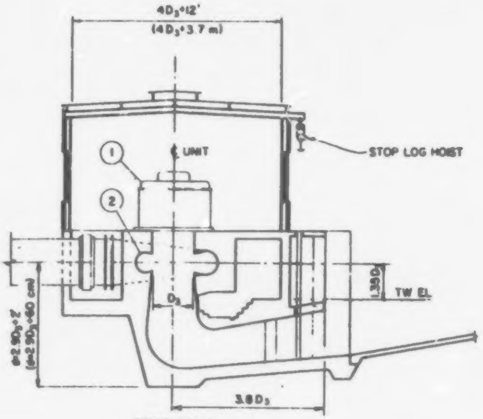
NOTES:

1. INTAKE DESIGN IS ENTIRELY SITE SPECIFIC. ALL ASPECTS OF THE RIVER AND THE SURROUNDING BANKS MUST BE CONSIDERED WHEN LOCATING THE INTAKE.
2. SURGE TANKS ARE NOT SHOWN. THEY REQUIRE SITE SPECIFIC DESIGN AND WOULD ONLY COMPRISE ABOUT 5 PERCENT OF PENSTOCK CONSTRUCTION COST, IF REQUIRED.

INTAKE DETAILS
FIGURE 3.6


TURBINE SHUTOFF VALVE
①
⑦
⑧
④
℄ PENSTOCK
STOP LOG SLOT
A
℄ UNIT
TAILRACE
$3.3D_3$
$4D_3+12'$
$(4D_3+3.7 m)$
⑥
℄ UNIT
⑨
③
⑤
ACCESS

PLAN


$4D_3+12'$
$(4D_3+3.7 m)$
①
℄ UNIT
STOP LOG HOIST
②
$1.3D_3$
TW EL
$D_3$
$\theta+2.9D_3+2'$
$(\theta+2.9D_3+60 cm)$
$3.8D_3$

SECTION A

Equipment
1. Generator
2. Turbine
3. Governor
4. Generator Breaker
5. Control Panel
6. Neutral Ground Cubicle
7. Cooling Pumps
8. Sump Pumps
9. Air Compressor and Tank

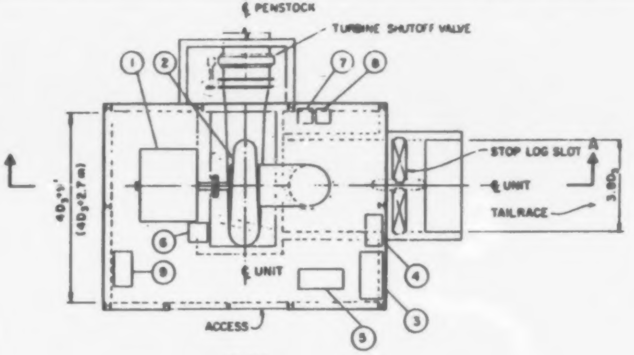
NOTES:
1. Arrangement and equipment are schematic.
2. Layout, equipment and dimensions shown may vary according to site specific power plant conditions.

**POWERHOUSE LAYOUT 1**

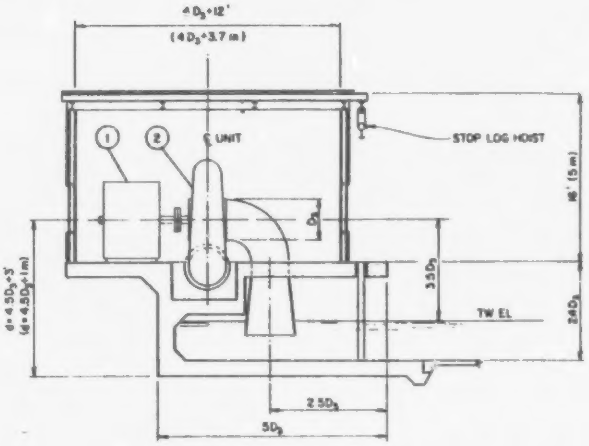
Powerhouse Layout — Vertical Francis Turbine
(WPRS - USA)

FIGURE 3·7·1

8848


℄ PENSTOCK
TURBINE SHUTOFF VALVE
1
2
7
8
STOP LOG SLOT
A
℄ UNIT
TAILRACE
$3.8D_3$
$4D_3+9'$
$(4D_3+2.7m)$
6
9
℄ UNIT
4
3
ACCESS
5

PLAN


$4D_3+12'$
$(4D_3+3.7m)$
1
2
℄ UNIT
STOP LOG HOIST
16' (5m)
$D_3$
$3.5D_3$
$2.4D_3$
TW EL
$d=4.5D_3+3'$
$(d=4.5D_3+1m)$
$2.5D_3$
$5D_3$

SECTION A

Equipment
1. Generator
2. Turbine
3. Governor
4. Generator Breaker
5. Control Panel
6. Neutral Ground Cubicle
7. Cooling Pumps
8. Sump Pumps
9. Air Compressor and Tank

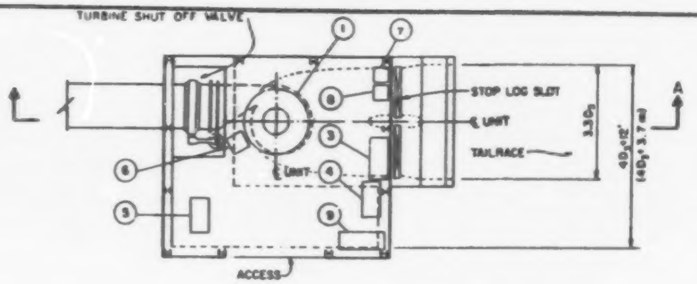
NOTES:
1. Arrangement and equipment are schematic.
2. Layout, equipment and dimensions shown may vary according to site specific power plant conditions.

**POWERHOUSE LAYOUT 2**

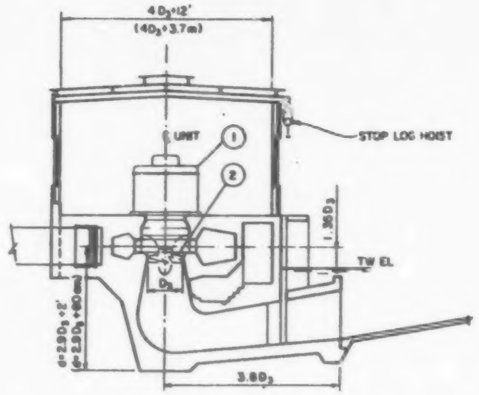
Powerhouse Layout — Horizontal Francis Turbine
( WPRS - USA )

FIGURE 3·7·2

5842
JUN 1982


TURBINE SHUT OFF VALVE
①
⑦
⑧
⑥
③
④
⑤
⑨
STOP LOG SLOT
℄ UNIT
℄ UNIT
TAILRACE
3.3D₃
4D₃+12'
(4D₃+3.7 m)
A
ACCESS

PLAN


4D₃+12'
(4D₃+3.7m)
℄ UNIT
①
②
STOP LOG HOIST
1.38D₃
TW EL
D₃
6'+2.9D₃+2'
(6'+2.9D₃+60cm)
3.8D₃

SECTION A

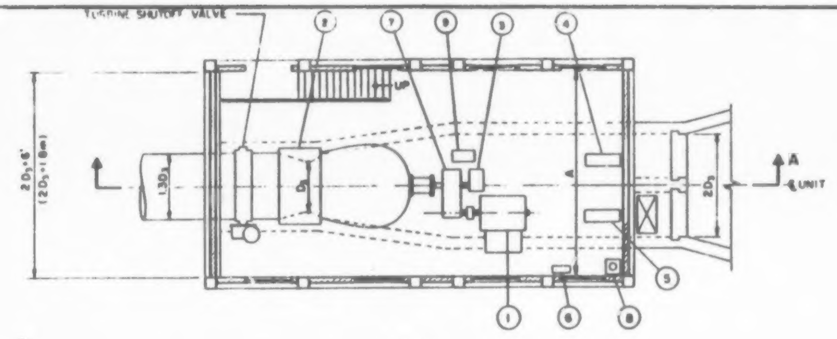
Equipment
1. Generator
2. Turbine
3. Governor
4. Generator Breaker
5. Control Panel
6. Neutral Ground Cubicle
7. Cooling Pumps
8. Sump Pumps
9. Air Compressor and Tank

NOTES:
1. Arrangement and equipment are schematic.
2. Layout, equipment and dimensions shown may vary according to site specific power plant conditions.

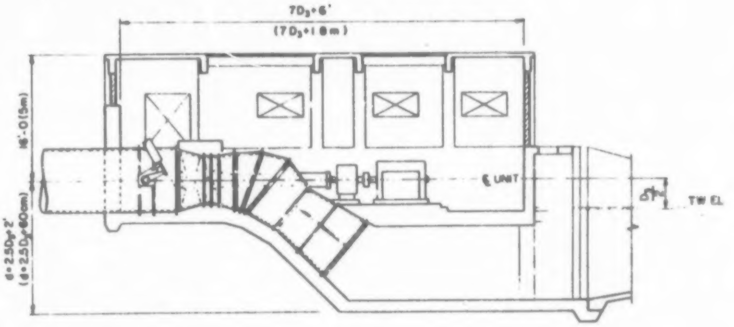
**POWERHOUSE LAYOUT 3**

Powerhouse Layout — Propeller Turbine with Penstock
(WPRS - USA)

FIGURE 3·7·3


TURBINE SHUTOFF VALVE
2
7
9
3
4
UP
2D3+6'
(2D3+1.8m)
1.3D3
D3
A
2D3
A
℄ UNIT
5
1
6
8

PLAN


7D3+6'
(7D3+1.8m)
16'-0(5m)
d+2.50D3+2'
(d+2.50D3+60cm)
℄ UNIT
TW EL

SECTION A

Equipment
1. Generator
2. Turbine
3. Governor
4. Generator Breaker
5. Control Panel
6. Neutral Ground Cubicle
7. Speed Increaser
8. Sump Pumps
9. Pressure Set

NOTES:
1. Arrangement and equipment are schematic.
2. Layout, equipment and dimensions shown may vary according to site specific power plant conditions.

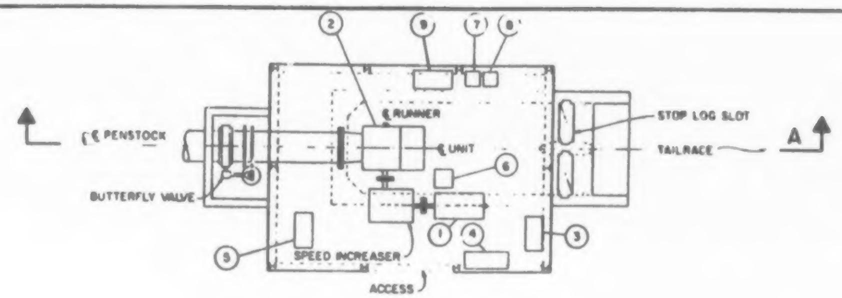
**POWERHOUSE LAYOUT 4**

Powerhouse Layout — Tubular Turbine with Penstock

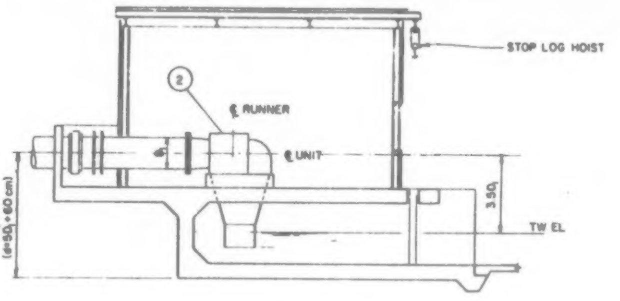
(WPRS - USA)

FIGURE 3·7·4

5842


2
9
7
8
℄ RUNNER
℄ PENSTOCK
℄ UNIT
STOP LOG SLOT
TAILRACE
A
6
BUTTERFLY VALVE
1
4
3
5
SPEED INCREASER
ACCESS

PLAN


STOP LOG HOIST
2
℄ RUNNER
℄ UNIT
3.50
TW EL
ϕ=50+2
(ϕ=50+60 cm)

SECTION A

Equipment
1. Generator
2. Turbine
3. Governor
4. Generator Breaker
5. Control Panel
6. Neutral Ground Cubicle
7. Cooling Pumps
8. Sump Pumps
9. Air Compressor and Tank

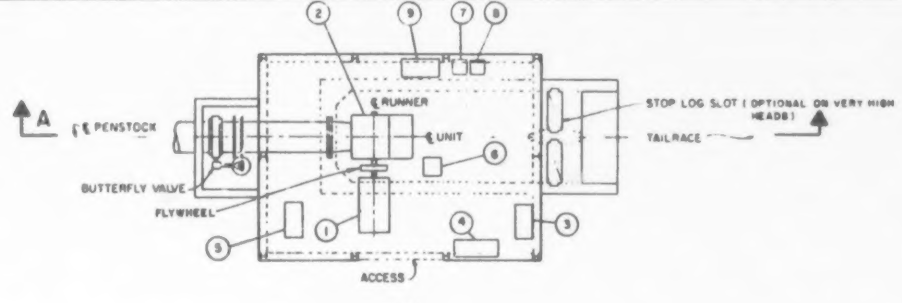
NOTES:
1. Arrangement and equipment are schematic.
2. Layout, equipment and dimensions shown may vary according to site specific power plant conditions.

## POWERHOUSE LAYOUT 5

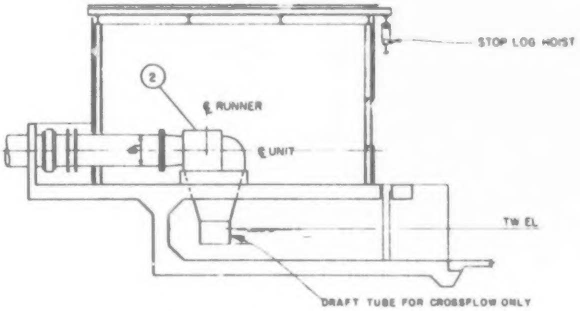
Powerhouse Layout — Crossflow Turbine (Low speed)
(WPRS - USA)

FIGURE 3·7·5

5242


2
9
7
8
A
℄ PENSTOCK
℄ RUNNER
℄ UNIT
6
STOP LOG SLOT (OPTIONAL ON VERY HIGH HEADS)
TAILRACE
BUTTERFLY VALVE
FLYWHEEL
5
1
4
3
ACCESS

PLAN


STOP LOG HOIST
2
℄ RUNNER
℄ UNIT
TW EL
DRAFT TUBE FOR CROSSFLOW ONLY

SECTION A

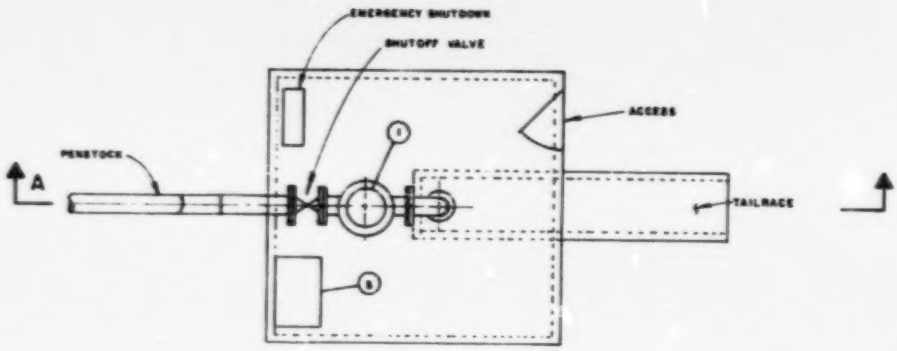
Equipment
1. Generator
2. Turbine
3. Governor
4. Generator Breaker
5. Control Panel
6. Neutral Ground Cubicle
7. Cooling Pumps
8. Sump Pumps
9. Air Compressor and Tank

NOTES:
1. Arrangement and equipment are schematic.
2. Layout, equipment and dimensions shown may vary according to site specific power plant conditions.

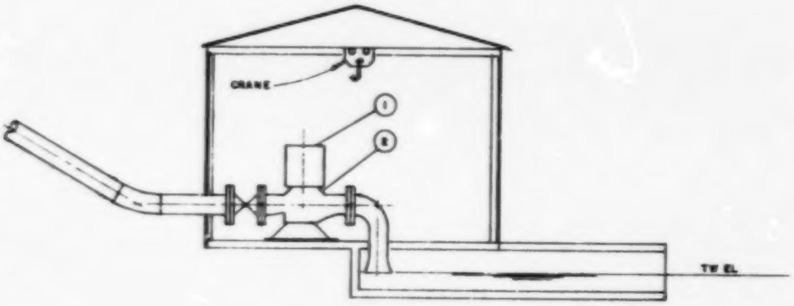
**POWERHOUSE LAYOUT 6**

Powerhouse Layout — Crossflow Turbine (High speed)
(WPRS - USA) or Pelton turbine

FIGURE 3·7·6


EMERGENCY SHUTDOWN
SHUTOFF VALVE
ACCESS
PENSTOCK
A
1
TAILRACE
3

PLAN


CRANE
1
2
TW EL

SECTION A

**Equipment**

1. Generator
2. Turbine
3. Control panel

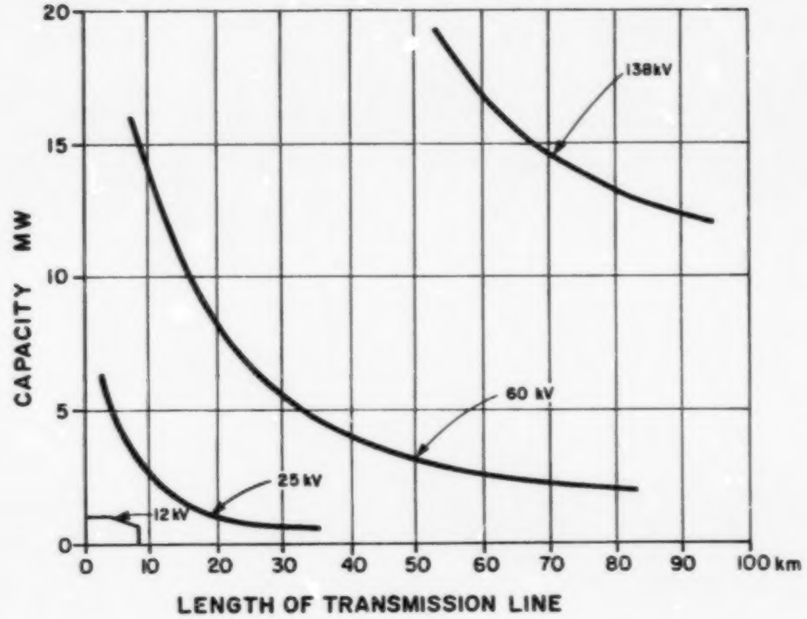
NOTES

1. Arrangement and equipment are schematic.
2. Layout, equipment and dimensions shown may vary according to site specific power plant conditions.

## POWERHOUSE LAYOUT 7

Powerhouse Layout - Reversible Pump/Induction Generator for plant less than 50 Kw

FIGURE 3·7·7



NOTES:

1. 20° C TEMPERATURE RISE
2. 10% POWER LOSS, 5% VOLTAGE DROP
3. THREE PHASE, 60 Hz
4. SWITCHING AND/OR SUBSTATION COSTS ARE SITE SPECIFIC, TO BE DETERMINED WITH LOCAL UTILITY

APPROXIMATE COSTS IN 1982 DOLLARS

12 kV - $50,000/km
25 kV - $50,000/km
60 kV - $60,000/km
138 kV - $80,000/km

TRANSMISSION LINE SIZING
FIGURE 3.8

[illegible]

## LIST OF EQUIPMENT SUPPLIERS

## TURBINES AND PACKAGES

### CANADIAN

1. BARBER HYDRAULIC TURBINES
   P O Box 340 Port Colburne, Ontario L3X 5W1

2. DEPENDABLE TURBINES
   3005 Murray Street, Port Moody, B C V3H 1X3

3. DOMINION BRIDGE SULZER INC
   P O Box 555 Lachine Quebec, Canada H8S 4E7

4. SMALL HYDRO ELECTRICS CANADA
   P O Box 54 Silverton, B C V0G 2B0

5. SOLACE ENERGY CENTRE
   2425 Main Street, Vancouver, B C

### FOREIGN (Canadian Agent)

1. GILKES TURBINES (ELECTRIC POWER EQUIPMENT LTD)
   1285 Homer Street, Vancouver, B C V6B 2Z2

2. THE JAMES LEFFEL AND CO LTD
   426 East Street, Springfield, Ohio USA 45501

3. OSSBERGER TURBINES (GORDON RUSSELL LTD)
   7600 Alderbridge Way, Richmond, B C V6X 2A2

4. VOEST/KOESLER TURBINES/
   (INDUSTRIAL HEAT ENGINEERING LTD)
   680 Raymur Avenue, Vancouver, B C V6A 2R1

## GENERATORS

**NOTE: Generator manufacturers must be given complete information on the turbine characteristics (preferably labelled drawings) before proper responses to enquiries can be made.**

1. KATO ENGINEERING (FINNING POWER PRODUCTS)
   555 Great Northern Way, Vancouver, B C

2. SIMSON-MAXWELL LTD
   1380 W 6th Avenue, Vancouver, B C

3. SIMPSON POWER PRODUCTS
   5271 Regent, Burnaby, B C

## GOVERNORS

1. WOODWARD GOVERNOR COMPANY
   5001 N Second Street, Rockford, Illinois USA 61101

2. THOMSON AND HOWE ENERGY SYSTEMS INC
   Site 17 Box 2 S.S. 1
   Kimberley B C V1A 2Y3

# TURBINE DATA SHEET

LOCATION: ______________________ DATE ______________________

Address for Correspondence: ______________________

______________________

______________________

Flow of Water: ______________________

Gross and Net Head: ______________________

Power Requirement: ______________________

Length Diameter and Penstock Type: ______________________

Reservoir Capacity: ______________________

Isolated or Parallel Operation: ______________________

Number of Units: ______________________

Existing Facilities: ______________________

Manual or Automatic Operation ______________________

Elevation of Plant Above Sea Level ______________________

Desired Height above Tailwater ______________________

Sediment Content of Water Supply ______________________

Will the turbine run at partial loads for long periods? ______________________

## GENERATOR DATA SHEET

### GENERATOR

Model:

Type:

kW: kV.A

Volts:

Power Factor: Phase

Wire: Pole

Cycle: RPM

Rotation:

Outlet Location:

Temp Rise:

Bearings:

Insulation:

Coupling:

Shaft Size:

Exciter:

### PRIME MOVER DATA

Connection Details:

Maximum Speed (Runaway):

Flywheel Characteristics:

Common Base or Floor Mount:

### CONTROL PANEL

Type: Alarms

Location: Annunciation

Meters Required: Parallel Operation

Circuit Breaker: Voltage Adjustment

# APPENDIX 5

# HYDROLOGY INFORMATION

# APPENDIX 5

## CONTENTS

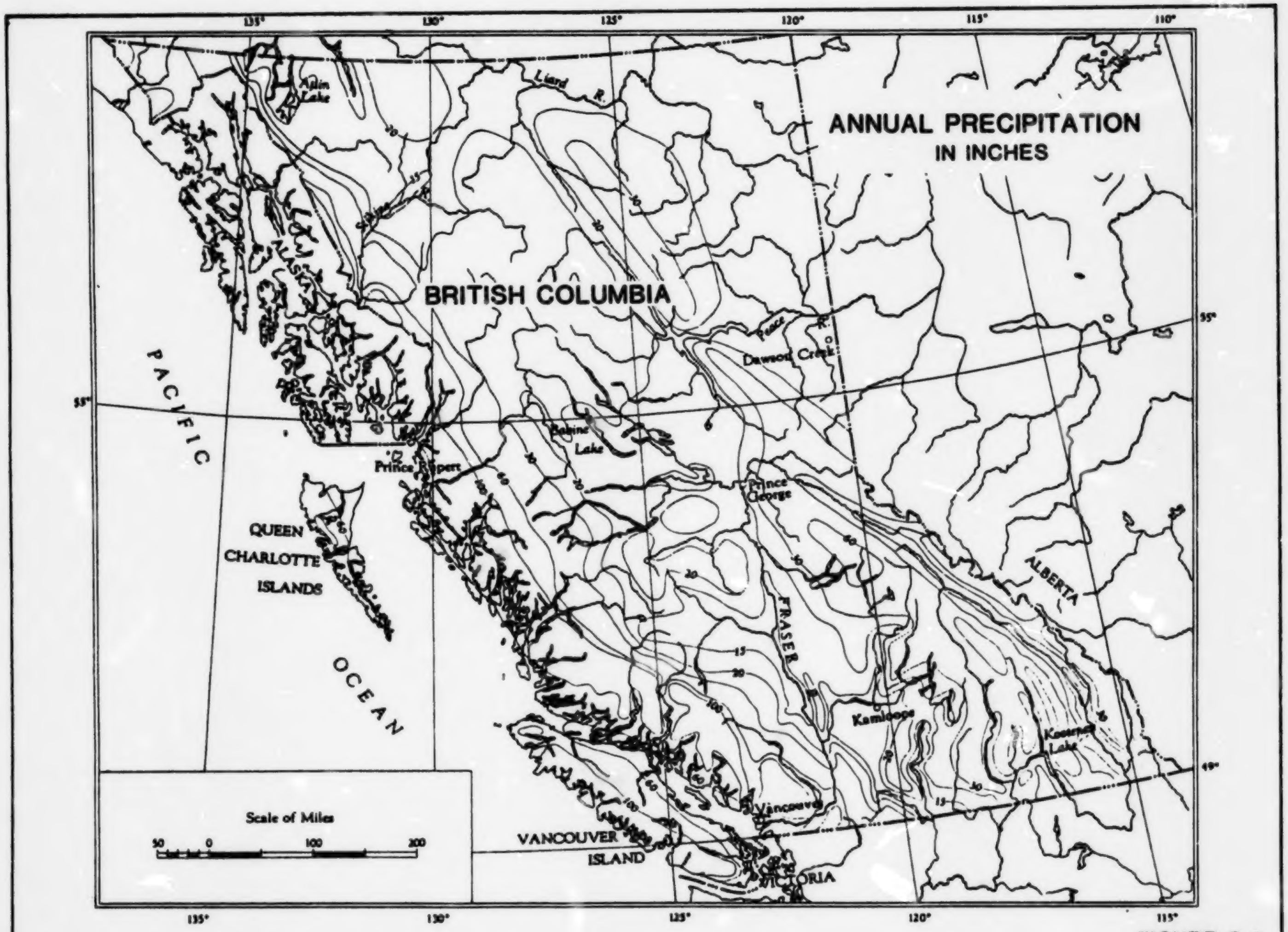
FIGURES

5.1 ANNUAL PRECIPITATION

5.2.1 ANNUAL RUNOFF (SOUTHERN B C)

5.2.2 ANNUAL RUNOFF (NORTHERN B C)

5.3 FIRMNESS FACTORS

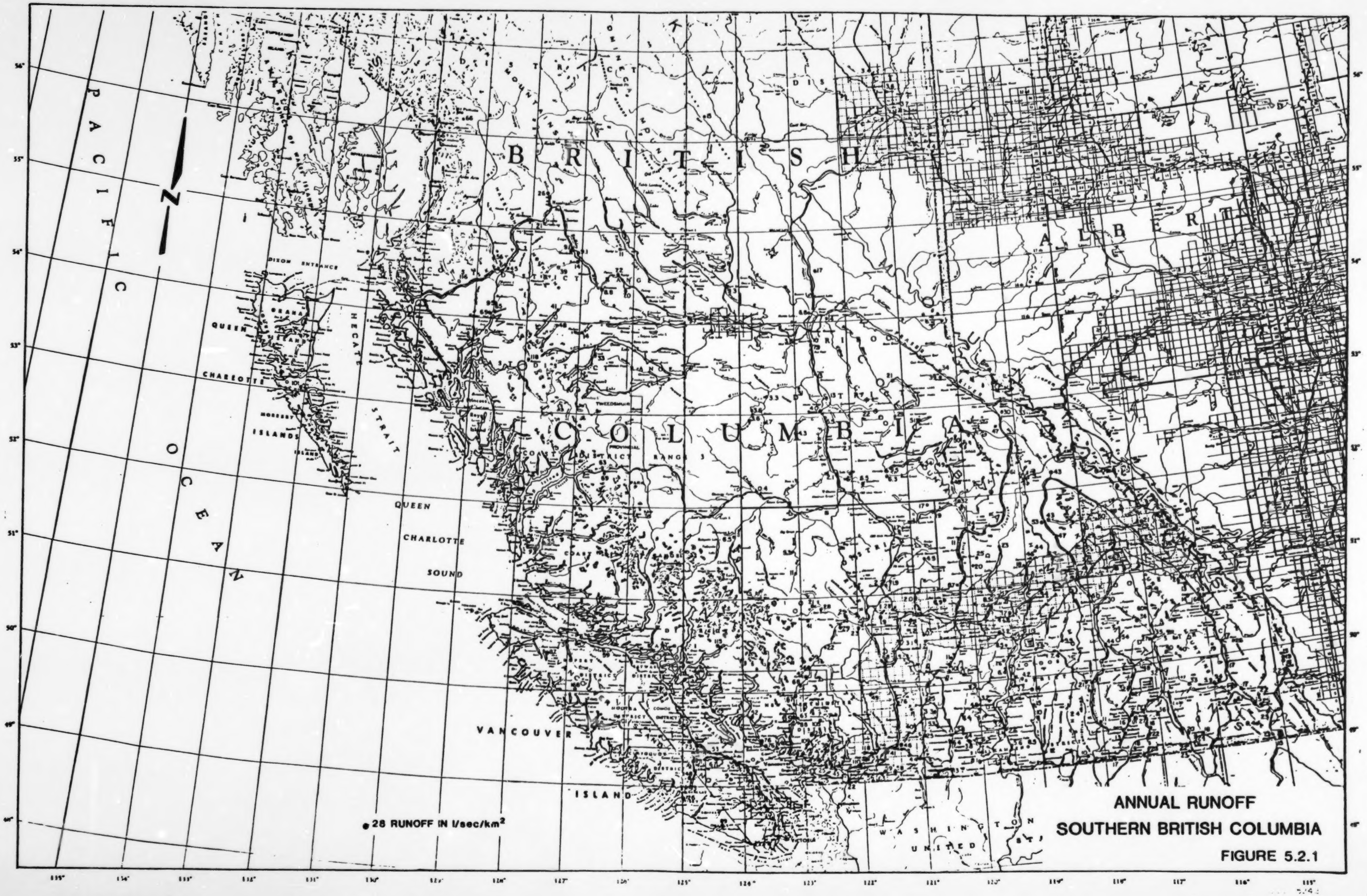


ANNUAL PRECIPITATION
IN INCHES
BRITISH COLUMBIA
ALBERTA
ALASKA
PACIFIC
OCEAN
QUEEN
CHARLOTTE
ISLANDS
VANCOUVER
ISLAND
VICTORIA
Vancouver
Kamloops
Kootenay Lake
FRASER
Prince George
Dawson Creek
Peace R.
Babine Lake
Prince Rupert
Liard R.
Atlin Lake
Stikine
Scale of Miles
50
0
100
200
135°
130°
125°
120°
115°
110°
55°
49°
10
15
20
30
40
60
100

FIGURE 5.1

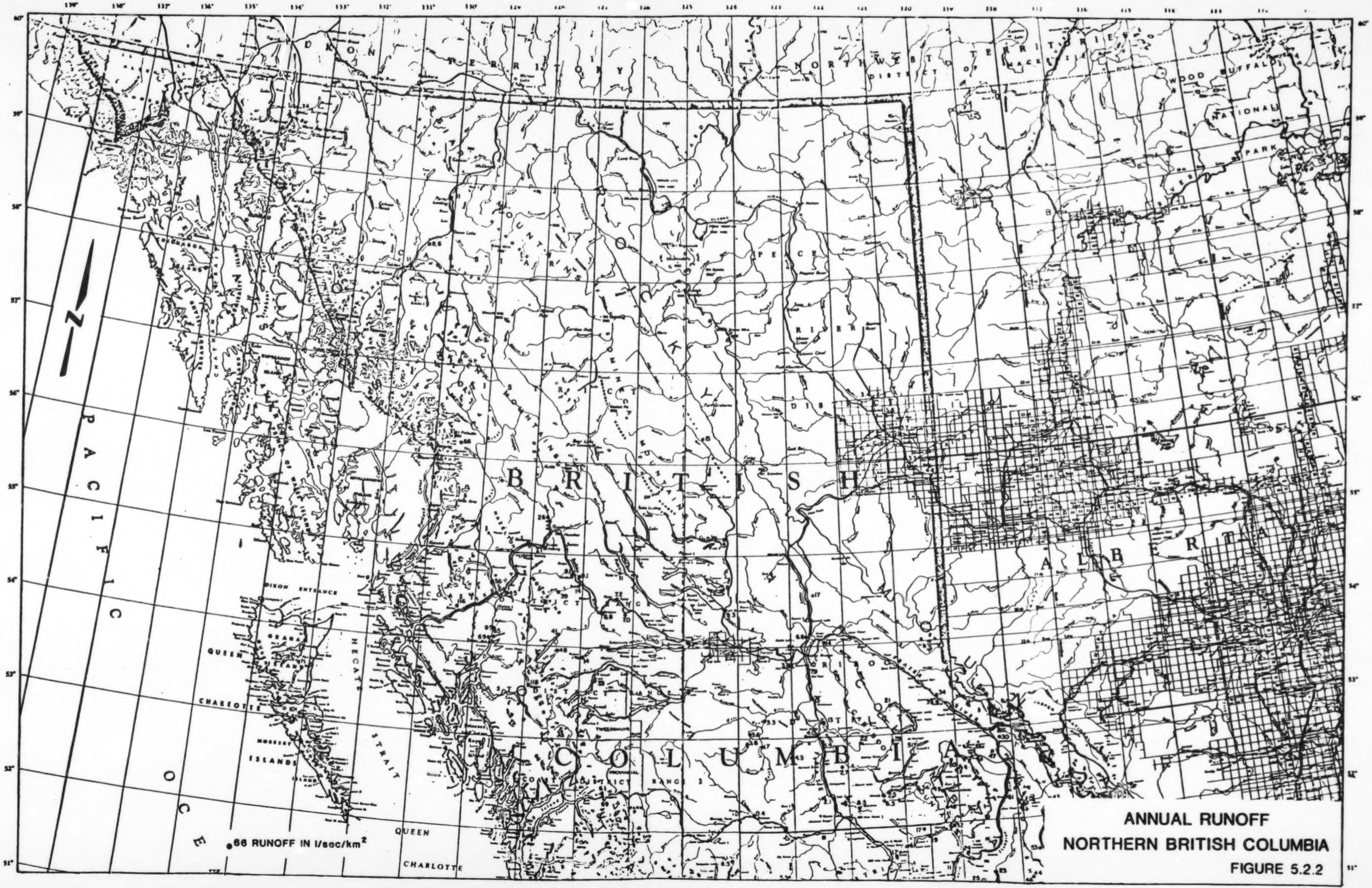
5242

UEC 1983

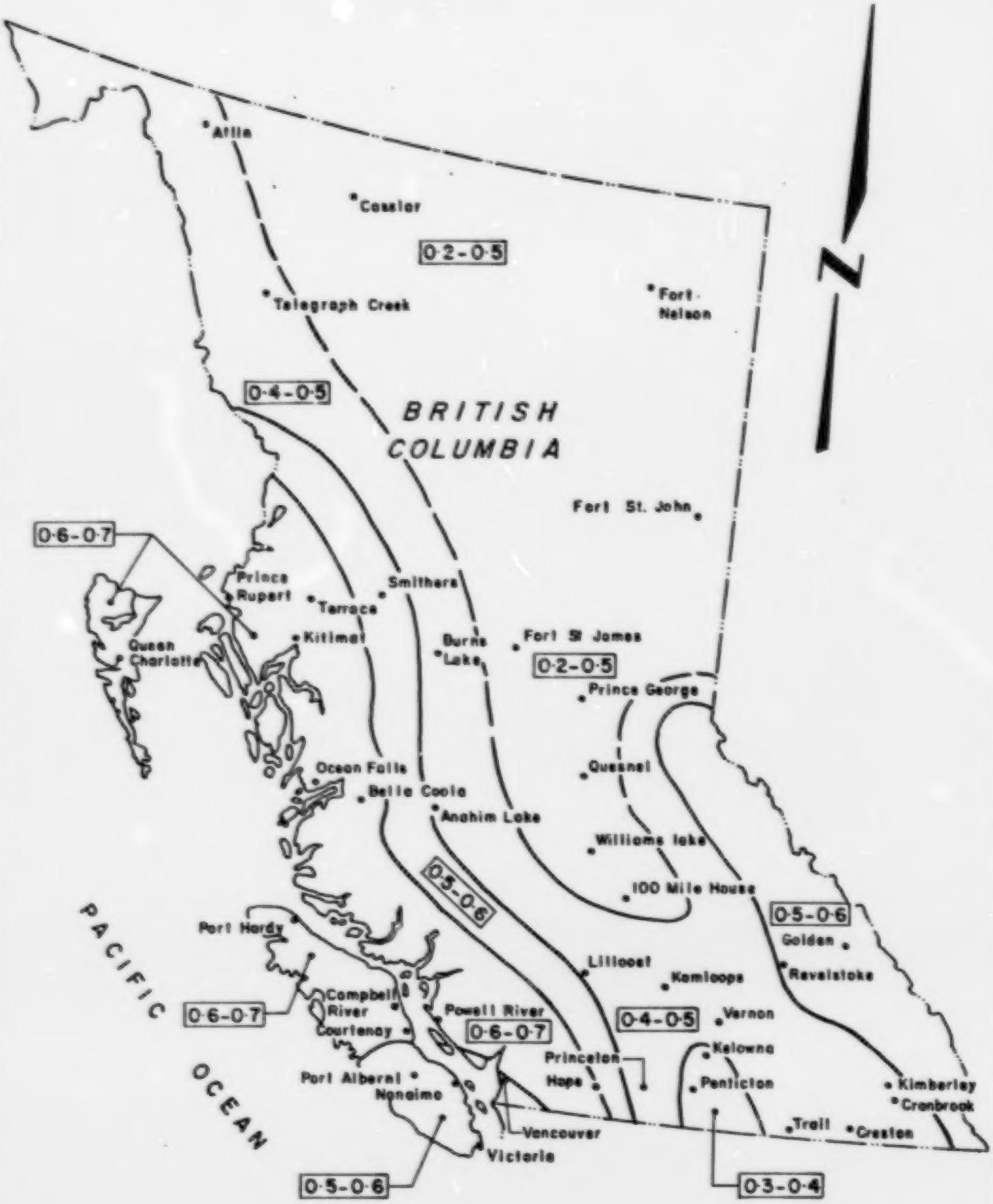

N
PACIFIC
OCEAN
BRITISH
COLUMBIA
ALBERTA
DIXON ENTRANCE
QUEEN
CHARLOTTE
ISLANDS
HECATE
STRAIT
QUEEN
CHARLOTTE
SOUND
VANCOUVER
ISLAND
WASHINGTON
UNITED
● 28 RUNOFF IN l/sec/km²
56°
55°
54°
53°
52°
51°
50°
49°
48°
135°
134°
133°
132°
131°
130°
129°
128°
127°
126°
125°
124°
123°
122°
121°
120°
119°
118°
117°
116°
115°

ANNUAL RUNOFF
SOUTHERN BRITISH COLUMBIA

FIGURE 5.2.1


YUKON TERRITORY
NORTHWEST TERRITORIES
DISTRICT OF MACKENZIE
WOOD BUFFALO NATIONAL PARK
BRITISH COLUMBIA
ALBERTA
PEACE RIVER
PACIFIC OCEAN
DIXON ENTRANCE
QUEEN CHARLOTTE ISLANDS
HECATE STRAIT
QUEEN CHARLOTTE
N
60°
59°
58°
57°
56°
55°
54°
53°
52°
51°
139°
138°
137°
136°
135°
134°
133°
132°
131°
130°
•66 RUNOFF IN l/sec/km²

ANNUAL RUNOFF
NORTHERN BRITISH COLUMBIA
FIGURE 5.2.2


N
BRITISH COLUMBIA
PACIFIC OCEAN
Atlin
Cassiar
Telegraph Creek
Fort Nelson
Fort St. John
Prince Rupert
Terrace
Smithers
Kitimat
Queen Charlotte
Burns Lake
Fort St James
Prince George
Quesnel
Ocean Falls
Bella Coola
Anahim Lake
Williams lake
100 Mile House
Port Hardy
Golden
Revelstoke
Lillooet
Kamloops
Vernon
Campbell River
Courtenay
Powell River
Kelowna
Princeton
Hope
Penticton
Port Alberni
Nanaimo
Kimberley
Cranbrook
Trail
Creston
Vancouver
Victoria
0·2–0·5
0·4–0·5
0·6–0·7
0·2–0·5
0·5–0·6
0·5–0·6
0·6–0·7
0·6–0·7
0·4–0·5
0·5–0·6
0·3–0·4

$$\text{FIRMNESS FACTOR} = \frac{\text{ANNUAL ENERGY (kWh)}}{\text{INSTALLED CAPACITY (kw)} \times 8760 \text{ hrs}}$$

FIRMNESS FACTORS
FIGURE 5.3

# APPENDIX 4

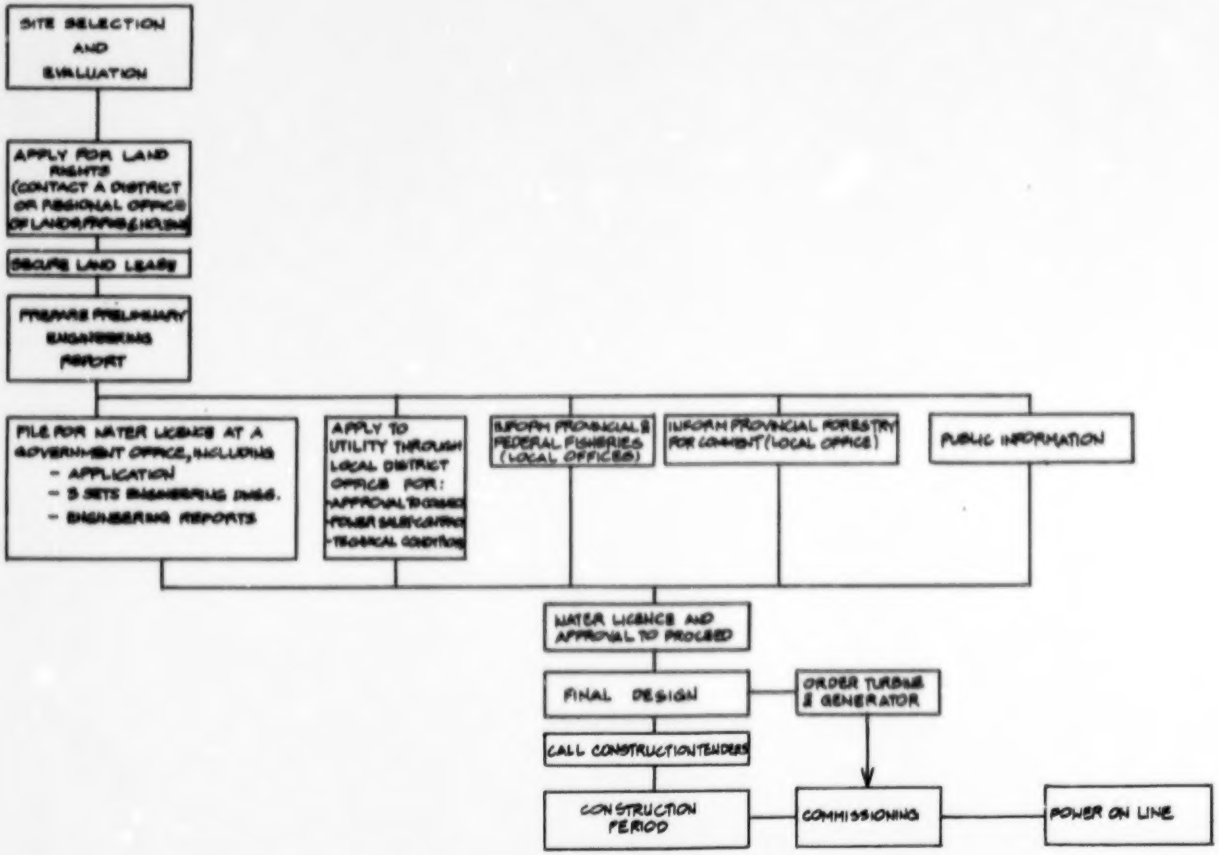
# IMPLEMENTATION OF A SMALL HYDRO POWER PROJECT

# APPENDIX 4

## CONTENTS

FIGURE

4.1 IMPLEMENTATION OF A SMALL HYDRO POWER PROJECT


SITE SELECTION AND EVALUATION
APPLY FOR LAND RIGHTS (CONTACT A DISTRICT OR REGIONAL OFFICE OF LANDS,PARKS & HOUSING
SECURE LAND LEASE
PREPARE PRELIMINARY ENGINEERING REPORT
FILE FOR WATER LICENCE AT A GOVERNMENT OFFICE, INCLUDING
- APPLICATION
- 5 SETS ENGINEERING DWGS.
- ENGINEERING REPORTS
APPLY TO UTILITY THROUGH LOCAL DISTRICT OFFICE FOR:
-APPROVAL TO CONNEC
-POWER SALES CONTRAC
-TECHNICAL CONDITIONS
INFORM PROVINCIAL & FEDERAL FISHERIES (LOCAL OFFICES)
INFORM PROVINCIAL FORESTRY FOR COMMENT (LOCAL OFFICE)
PUBLIC INFORMATION
WATER LICENCE AND APPROVAL TO PROCEED
FINAL DESIGN
ORDER TURBINE & GENERATOR
CALL CONSTRUCTION TENDERS
CONSTRUCTION PERIOD
COMMISSIONING
POWER ON LINE

IMPLEMENTATION OF A SMALL HYDRO POWER PROJECT

FIGURE 4.1

POOR

QUALITY

ORIGINAL